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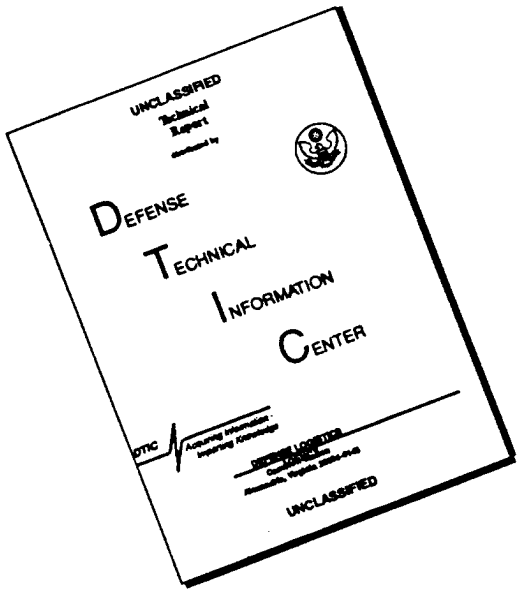


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This report represents the first year of our investigation. In the first year we completed the training and testing of 37 women. We also completed testing of 35 men for strength/power gender comparison controls. In order to determine the effects of different types of training programs this study will utilize 3 years to complete all of the training and testing required to gain the needed n size for 6 experimental groups and a control group of men for gender based comparisons of strength/power performances. In this study military relevant tasks, strength/power testing, neuromuscular responses (e.g., EMG responses), muscle morphology via magnetic resonance imaging, immune function, and endocrine profiles related to anabolic and catabolic hormones will all be determined to gain an underlying biological understanding of the adaptational responses in women to different types of resistance and endurance training programs.

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William J. Kraemer

PI - Signature

Date

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# INTRODUCTION

***Project Time Line.*** This annual report covers the work that has been accomplished in the first year of our three year investigation. Due to the need for appropriate "n" sizes in each of the experimental groups, this project requires the full three years to complete all of the data collection for the six groups of women. Additionally, over this three year period we will be collecting strength and power performance data in a control group of men for gender-based comparisons. Thus, any final analyses related to the longitudinal training questions posed in this investigation will not be available until the final report of the project. Where appropriate, we will utilize cross-sectional data analyses to generate new information and publications related to our project. Our approach is to first complete the four experimental groups involved with different resistance training/endurance training protocols. The information gained on program design in the first two years will then be used to design the field training protocol for the final year. We will then in the final year complete both the endurance training and field training experimental groups. The strength and power control testing of men will be accomplished in an ongoing fashion until we complete the needed number of subjects.

***Theoretical Background of the Study.*** With the changing roles of women in the United States Army, the physical demands will only increase as we move into the 21st century. The primary physical demands of the majority of military occupational specialties (MOS) are related to muscular strength and power capabilities where women, on average, produce in a range of 35-86% of men [1-3]. Comparatively speaking, women average only 56% of the upper body strength and power of men; they do somewhat better when one compares lower extremity performance (71%). The primary problem is that in order for the average woman to gain parity with the average man, she must dramatically increase her strength (i.e., up to 65% increases required depending upon muscles involved). Others have tried to meet this goal but have fallen short, primarily because their heavy resistance training programs have been relatively unsophisticated and have not been carried out long enough.[4-7] Our investigation utilizes more advanced training programs of longer duration for women which appears to be required to achieve higher levels of adaptation in muscle strength and power when compared with average men.[1,3] To date, limited information is available on more advanced training programs in women. Except for the anecdotal knowledge that certain women athletes develop superior muscle strength, power, and size when compared to average men, our knowledge remains incomplete. Finally, we feel that in order to fully understand potential physiological limitations, mechanisms of adaptation, and

the impact that advanced resistance training programs may have on the health status of women, a strong underlying biological component was necessary for the investigation.

Fully $^{1}/_{3}$ of the non-combat operations that women could theoretically do are those which require the soldier to lift, carry, push, or pull loads in excess of 40 kg.[1,8] However, the most recent information has shown that only 30-40% of women could actually perform these types of tasks if they were required to do so. Furthermore, there are good reasons to believe that this situation can be improved by new strategies that involve state-of-the-art resistance training regimens.[9]

***Contribution of Upper Body Strength to Functional Abilities.*** The contribution of upper body strength to whole body performance has never been fully evaluated. In fact, the only limited data available are those in men in which the contribution of upper body strength training to performance or tasks relevant to the military was defined. For example, in 1987 the Principal Investigator studied the effects of upper body strength training in male soldiers on load bearing and performance in the Army Physical Fitness Test (APFT).[10] Upper body strength training, together with aerobic endurance training, was done for three months. In that study, the experimental design included the following four groups: 1) total body strength and endurance training; 2) upper body strength and endurance training; 3) endurance training only; and 4) strength training only. Only those in the upper body and total body strength training groups improved in both APFT measures and two mile load (backpack load of 44.7 kg) bearing tasks of a similar magnitude. These data showed that aerobic endurance, upper body strength, and upper body power are the primary contributors to APFT and load bearing performance. Since women are at an even greater disadvantage in terms of upper body strength and power, we hypothesize that the contribution of upper body strength and power to physical fitness and load bearing are the key targets for heavy resistance training.

All military-relevant tasks involve strength and power contributions from the upper body musculature. A lower absolute magnitude of upper body muscle tissue is thought to be the primary contributor to reduced strength and power capabilities of women.[3,2] Thus, enhancing the quantity and quality of upper body muscle tissue may well contribute to the majority of the enhanced physical performance capabilities in women. To date, no studies have directly examined the contribution of upper body resistance training in women. Thus, our investigation will study the role of improving upper body strength and power and determine its impact on performance.

***Strategies for Enhancing Strength, Power, and Muscle Size in Women.*** Resistance training programs can be specifically designed to enhance both muscle tissue mass and/or neuromuscular function.[3,9] The neural component enhances strength and power capabilities via neural mechanisms while placing little or minimal demand for the hypertrophy of activated muscles.[11,12] Conversely, the muscle tissue component results primarily in the enhancement of strength and power via increase in muscle size due to protein accretion and increased hypertrophy.[13,14] These are the primary physiological mechanisms by which resistance training is thought to produce increases in strength, power, and performance.

Training programs which focus on the neural component utilize higher intensities (i.e., percentages) of the 1 repetition maximum (1 RM) in that training.[15] They are characterized by longer rest periods between the sets and exercises as well as lower volumes of work. Conversely, programs which focus on the muscle tissue component utilize a lower range of percentages of the 1 RM, shorter rest periods between sets and exercises, and higher volumes of work[15]. Thus, strength and power performance is mediated by two different adaptational routes; those routes can be manipulated and studied independently for their effectiveness.

For many years it had been thought that women gained strength primarily through neural mechanisms because only small changes in muscle size were observed.[4,3] To be fair, it must be pointed out that all of the studies reaching this conclusion did not use an optimal muscle hypertrophy training program; nor did they examine training responses in a period of time that would be long enough to reveal adaptations in the muscle tissue component. A recent study published by Staron *et al.* (1994),[16] demonstrated that in the first 8 weeks of training, no changes in muscle fiber size take place in men or women. However, alterations in the types of myosin heavy chain protein and muscle enzymes do. Thus, while neural adaptation may appear to predominate in the early phases of training prior to observing muscle hypertrophy, this could reflect the need for alterations in the muscle proteins prior to the time that protein accretion starts to occur to any significant extent.[15] Clearly, longer periods of training time will be needed to fully evaluate the potential for other physiological strategies to contribute to the goal of enhanced physical performance. Since muscle tissue mass is the ultimate limiting factor in muscle strength, a better understanding of the strategies that enhance it are of great value. Our approach evaluates the interaction between neural and hypertrophy components and seeks to optimize them. Our research

strategy enhances the chances to determine the best way to meet the overall physical training goal efficiently and effectively.

***Contributing Hormonal Factors.*** Short-term "normal" strength training in women usually does not lead to changes in serum levels of endogenous hormones beyond the normal physiological range.[18] However, the balance between anabolic (e.g., testosterone, growth hormone, insulin-like growth factors) and catabolic (e.g., cortisol) hormones is likely to become increasingly important especially during prolonged resistance training. Not all types of workouts produce the same alterations in anabolic and catabolic hormonal responses.[19-21] In fact, hormonal balances and responses to heavy resistance training follow a distinctly different pattern for a "strength/power" workout compared to a "muscle tissue/hypertrophy" workout.[20] Because hormones are the driving force by which cells make changes to adapt to their environmental needs, and because changes at the cellular level ultimately translate into changes in whole body function, hormone measurements in our various test subject groups are important to the underlying understanding of the mechanisms of adaptation. The fact that the anabolic/catabolic hormone ratio changes between "strength/power" vs. "muscle tissue/hypertrophy" [22,23,11] lends additional validity to our experimental design.

Growth hormone is poorly named because it is a metabolic hormone which controls multiple organ systems (muscular, skeletal, immune, and liver) throughout life in addition to promoting bone growth during adolescence. It is therefore not surprising that there is 800x more GH in the pituitary than any other hormone! There is compelling evidence to show that multiple forms of hGH molecules are found in both the human pituitary gland and in human plasma.[25-28] The evidence that some of these forms have different bioactivity (b) to immunoactivity (i) ratios is equally compelling. For example, the b/i activity ratios of human plasma is 200![26] This is an astonishing number because it shows that the technique conventionally used to measure blood levels of hGH (i.e., radioimmunoassay) fails to detect forms of the molecule which are biologically relevant, i.e., that promote bone and muscle growth. There are good reasons to believe that the kind and amount of GH released from cells of the pituitary gland depends upon disease state and general state of fitness.

It is our belief that anabolic hormones are the key, primary physiological regulators that ultimately control and limit the body strength of the human female. Our experimental design allows us to monitor what we believe to be the most important anabolic hormones (GH, IGF-1, and testosterone) in such a way that we will have a much better picture of the

optimal chemical environment around muscle tissue that is responsible for achieving the desired result: increased muscle strength/power of the human female.

***Heavy Resistance Training In Relation To Women's Health and Immune Function.*** The physical demands of a soldier in the Army are directly analogous to that of an athlete where advanced physical preparation or training is required for meeting the demands of the job.[1,29] When additional physical stress is added to a lifestyle, additional physiological stress is usually observed. That stress can seriously compromise toleration of rigorous training programs of the type we are studying. Herein we face a potential dilemma; viz. how do we optimize women's training programs in a situation where the high level of physical training could negatively affect the health status of the individual? Obviously we need a simple, straightforward way to monitor health status; we propose to do so via well-known techniques that collectively are classified as immunology.

The immune system not only protects from acute insult delivered by infections and disease-causing agents but it also maintains a constant state of health by response to and modulation of many internal signals. In this specific regard, the immune system probably interacts with every other organ system in the body. The strongest evidence to date shows that cells of the nervous, endocrine, and immune system communicate via soluble mediators, hormones, interleukins, and their cytokines. Evidence that both estrogen and androgens can directly affect immune organs and cells is compelling.[30] At the whole body level, the immune response (cell-mediated and humoral) of females is generally greater than that of men. Women are usually less susceptible to challenge with infectious and toxic agents. In addition, certain autoimmune diseases are much more likely to occur in males. The need for the women to adapt immunologically to pregnancy is perhaps the most clear-cut example of gender differences in immune responsiveness. Furthermore, the immune system is affected by stress hormones. One such stressor is exercise; it dramatically increases amounts of immune cell interactive hormones such as cortisol, growth hormone, prolactin, and catecholamines.[18,31,32]

Initial evidence shows that women do not tolerate high intensity power training as well as men. This phenomenon is reflected by a plateau (i.e., leveling off) in strength gains observed at about 2 to 4 months.[23,33] Plateauing could represent (1) a shift in the physiological strategies that the body uses as it changes from primarily neural adaptations to primarily muscle hypertrophy adaptations, or (2) reflect an overtraining syndrome due to the associated stress at the cellular level related to muscle cell remodeling. The latter

stress is associated with increased protein accretion and turnover that is needed for muscle hypertrophy and involves "cleaning up" the cell from the exercise-induced damage associated with the remodeling process rather than fighting disease.

Viewed together, these results not only underscore the complexity of the problem, but also validate our thesis that design of the resistance training program is not simple, but can be manipulated in a scientifically predictable way to achieve a desired result. The sheer physical stress associated with tissue remodeling of the neuromuscular unit can lead to stress on the immune system, thus hampering training progress due to illness.[34] Thus, understanding the health impacts, physiological adaptations, and performance changes of such advanced training is a vital issue related to women's health.

***Statement of Work.*** The statement of work for this investigation is provided in this annual of year one to overview our primary work tasks related to this investigation. We have addressed all of the different work statements over the first year of the project.

**STATEMENT OF WORK**

1. Pilot test all experimental variables and equipment
2. Recruit, gain informed consent, medically screen, familiarize, and pre-test women and men
3. Match, balance and randomize women into subject groups
4. Perform training familiarization
5. Initiate supervised physical training programs
6 Perform data collection at 0 (T-1),3 (T-2) and 6 (T-3) months for training groups
7. Perform biochemical and immunological assays
8. Perform magnetic resonance image scans of upper and lower limb musculature
9. Perform electromyographical and strength test evaluations
10. Coordinate with the United States Army Research Institute's Military Performance Division military relevant physical performance task tests at Penn State.
11. Develop computer data base management scheme and perform data entry and analyses over the course of the experimental period.

ï12. Utilize phase one weight room data to develop optimal strategies for program design of "field training" resistance program for year three.

ï13. Analyze data set and provide appropriate reports, physical training recommendations, and scientific publications on physical training of women.

# METHODS

Again, our approach is to first complete the four experimental groups involved with different resistance training/endurance training protocols. The information gained on program design in the first two years will then be used to design the field training protocol for the final year. We will then in the final year complete both the endurance training and field training experimental groups. The strength and power control testing of men will be accomplished in an ongoing fashion until we complete the needed number of subjects.

*Subject Characteristics* We have recruited in our first phase healthy young men and women in the age range of 18-32 years. The matching process involves a six women group with open spots for women in the field training and endurance training groups in year three. Thus, our goal has been to match and randomize and make sure that their are no significant differences between the groups for such variables as age, body mass, % body fat, androgen levels, activity background, menstrual cycle status, strength, and power prior to the start of the study. The project has been approved by our Institutional Review Board for Use of Human Subjects and all subjects after a briefing on the investigation are asked to give their informed written consent to participate. They are then medically screened (including EKG and pregnancy testing) by our physician who is a part of the research team.

*Experimental Design.* To test the various hypotheses set forth in this investigation, we will utilize 6 groups of women (4 experimental weight room training groups, an endurance training control group, and a field training group. We also will collect strength/power performance data on a group of men for gender comparisons. The training programs will consist of 6 months of training (3 days/week) with testing performed at 0, 3, and 6 month intervals in order to be able to accomplish all of the needed testing. Familiarization with training and testing protocols will limit gains which can be attributed purely to learning effects!

## EXPERIMENTAL GROUPS

**Women**

**Resistance Training/Endurance Training Groups (Years 1 and 2)**
1. Upper Body Strength/Power (targeted n size of 15-20)
2. Upper Body Hypertrophy/Strength Endurance (targeted n size of 15-20)
3. Total Body Strength/Power (targeted n size of 15-20)
4. Total Body Hypertrophy/Strength Endurance (targeted n size of 15-20)

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(Year 3)
5. Endurance Training Control Group (targeted n size of 15-20)
6. Field Training Group (targeted n size of 15-20)

**Men**

(Years 1 to 3)
Normative Male Comparison group (targeted n size of 100)

*Experimental Heavy Resistance Training Groups.* Subjects in these groups will all participate in a supervised endurance training program identical to that of the endurance training control group. In addition, each subject will perform the supervised resistance training program outlined for each program.[3,35] Periodized heavy resistance training programs are fully supervised and individualized as to progression in intensity, number of sets, rest between sets, and volume of exercise performed.[3,9,39] See Appendix 1 for example periodized progression cycles for each resistance training protocol. Variation will be provided over week of the training program within the range of program parameters where strength power groups lift weights only 8 RM or lower with longer rest periods and hypertrophy-strength endurance groups lift weights 8 RM and higher and use shorter rest periods. The exercises are similar, except for the obvious lack of lower body strength exercises in the upper body groups. The dramatic contrasts in the programs will allow us to see how much differentiation exists with resistance training program design in women. The 6 month duration of this training program is vital in the attempt to maximally affect the magnitude of training related adaptations and to determine if any plateaus exist for these training programs. Free weights and commonly available weight training machines will are used to perform the exercises.

*Endurance Training Control Group.* Due to the fact that the U.S. Army promotes aerobic endurance training as a part of the soldier's total fitness program, we feel that it is

vital that we utilize physically active women in this study.[36] Thus, to be consistent with a soldier's typical fitness program, all subjects will carry out a supervised endurance training program of three days a week for 30-45 minutes. It has been shown that endurance training of this magnitude does not interfere with strength or power development in women.[37]

*The Field Training Group.* This group will initiate its training program after the completion of the "weight room" study phase of this investigation. We must first utilize the most sophisticated training protocols and equipment to see if the gender gap in strength and power can be significantly minimized. Once we know the characteristics of the most effective resistance training programs in the weight room, we will determine how many of these adaptational changes can be achieved with various exercises in the field, not utilizing formal weight room equipment. Only partner exercises, common equipment resistance, manual resistance exercises, isometrics, and various types of plyometric drills will be utilized. Comparison of the field training and weight room results will indicate the potential utility of such physical training programs in the Army. Data from U.S. Army basic training demonstrate that many women soldiers gain strength with current physical training programs, but these gains are not enough to markedly impact MOS load demands for strength and power (Sharp, M. *et al.* USARIEM unpublished data).

*Normative Male Comparison Group.* In order to compare how the gains made by women in the different training programs directly affect performance relative to men, a normative group of men will be used in this investigation to provide data on muscle size (MRI), strength, power, and militarily relevant task performance tests. About 100 healthy men will be matched for age and activity background with the women in the training study. The goal will be to have a group of men who are representative of the average height and weight range of soldiers in the U.S. Army based upon data from Fitzgerald *et al.* (1986).[38]

**EXPERIMENTAL TESTS**

The following section of the report briefly overviews the experiemtal tests used in this investigation.

**Strength/Power Tests.** The Plyometric Power System (PPS)[40,41] was developed to overcome the injury risks and inefficiencies of other methods for the more sophisticated assessment of human muscular strength and power. To provide resistance for testing and training, the PPS uses a barbell to simulate a mass used in occupational and sporting activities. It is much more similar to normal human activity than are isokinetic devices which

require constant speed movement. The PPS is interfaced to a computer making it a very accurate measurement tool which provides detailed information concerning the kinematics and kinetics of the performance. The variables recorded include displacement, velocity, acceleration, force, and power output with respect to time as well as indices of explosive power performance such as rate of force development and time to peak force. The PPS allows the individual to be tested and trained under conditions of maximal power and strength output in an environment of total safety. Limiting catches prevent injury through falling or loss of control of the loaded bar and a specially designed electromagnetic braking mechanism can control the eccentric loading on the subject from zero to full bar weight. Vertical ground reaction force will be measured by means of an AMTI force platform, the amplified signals of which will be passed to a DT21-EZ analog to digital card (Data Translation) in a 80486DX computer running Windows 3.11. The digitized data will be stored on computer disk for later analysis. The force measurement system are calibrated prior to all testing sessions.

Three movements are to be tested: 1) The High Pull will involve the subject lifting the weight from the floor level to a position at chin level; 2) The Squat will be performed from a knee angle of 90 degrees flexion to a standing position with the bar held in the high back squat position; and 3) The Bench Press will involve pushing the bar vertically upwards from the chest position. The strength and power capacity of the subject will be assessed during the entire concentric exercise phase. During the first testing session, the subject's one repetition maximum (1 RM) load for each of the test movements will be determined.[42,43]

During subsequent test sessions the PPS will be loaded with 30%, 60% and 90% of the subject's previously determined 1 RM for the squat jump. Each subject will complete a single, maximal explosive effort with the required load. Three trials will be completed for each test movement. The order of the test movements and loads will be randomized among subjects to reduce the possible confounding effects of fatigue or boredom. A 1-2 minute rest period between attempts will be utilized. During each trial the PPS will record the displacement-time data, are being collected and stored for later analysis.

Maximal voluntary unilateral isometric peak force, force-time, and relaxation time parameters of the knee extensor muscles will be measured separately for the left and right leg. The subject is in a sitting position on a special chair (a modified version from Cybex) so that the knee angle will be 90°. The force output will be recorded using resistive force transducers in series with a chain securing the subject's leg. The subjects are instructed to

respond to a command by exerting their maximal force as rapidly as possible during a time period of 2.5-5.0 seconds. They will also be instructed to relax the force as fast as possible after the required contraction time and having reached their maximal force. Three to four maximal contractions will be recorded separately for the left and right leg until maximal peak force (N) is obtained. The force-time analysis will include the calculation of average force (N) produced during each consecutive time period of 100ms in duration from the start of the contraction as well as the maximal rate of rise of force production ($N \times s^{-1}$). The relaxation time curve will be analyzed in the relaxation phase of the contraction to record the time (ms) needed to relax the force. Only the actual relaxation time is analyzed without the reaction time to signal given for the start of the relaxation. In order to evaluate muscle activation relative to determining the changes in the neural component, electromyography is being utilized for isometric knee extensor tests.[11,23,33] During all trials, each subject will have silver/silver chloride surface electrodes attached over the belly of the prime mover muscles. Two active electrodes separated by 2 cm will be attached to the belly of each muscle and a third ground electrode attached to the lateral malleolus. The active electrodes will be aligned parallel with the fibers of the muscle under investigation. Before electrode application, each site will be shaved, cleansed with alcohol, gently abraded and a small amount of conductive gel applied to each electrode. The impedance between each electrode pair will be measured to ensure resistance is below 5000 Ohms. The signals will be amplified using a Noraxon EMG amplifier and the amplified myoelectric signals will be collected using a 80486DX computer running Windows 3.11 and a DT21-EZ analog digital card (Data Translation). The digitized data will be stored on a computer disk for later analysis.

EMG data will be quantified in two ways. 1) The average EMG will be calculated by full wave rectification followed by integration with respect to the time over the concentric phase, then divided by the time of the concentric phase. 2) Peak EMG will be calculated by integrating the rectified EMG over consecutive 50 ms time periods and determining the highest activity level.

***Resting and Exercise-Induced Blood Collections for Hormone and Immune System Analyses.*** Before and after the relative endurance strength test (6 x 10 RM), resting and post-exercise blood samples will be collected into appropriate serum, plasma, or whole blood collection tubes and then processed, centrifuged, and stored where appropriate at $-85^{o}$ C, and analyzed according to previously described methods for serum hormone concentrations for serum hormones[19,20,21,44,45] [testosterone, free testosterone, sex-

hormone-binding globulin, growth hormone(s)(bioactive [pre-post-training] and immunoreactive), cortisol, and insulin-like growth factor I]. In addition, hematocrit, hemoglobin, plasma volume shifts, and blood lactate, will be determined via standard methods we have previously used.[19] (see Appendix for assays set up on bioactive Growth hormone fractions)

In order to adequately monitor the immune system [pre-mid-post-training], white blood cell differential counts, mitogen responsiveness *in vitro*, and cytokine production will be measured. In addition, lymphocyte phenotyping will be carried out. Many of the immune stress measures will be identical to the Army's study of the stress associated with Ranger training and will allow comparison of stressors.[29]

1. Complete blood counts and white blood cell differential counts will be obtained on resting samples.
2. *Mitogen responsiveness in vitro.* Both T and B lymphocytes respond to appropriate mitogens in culture by activation leading to DNA synthesis. Standard protocols will be used for isolation of human mononuclear cells from blood using leukoprep separation techniques.[46] White blood cells will be resuspended in culture medium, RPMI-l640 plus l0% heat inactivated human AB serum and assayed in a 96 well microculture plate with T cell mitogens phytohemagglutinin-M (PHA), Concanavalin A (Con A), or tetanus toxoid (TT). The former are polyclonal, non-antigen specific stimulators; the latter will evoke a secondary antigen response. Pokeweed mitogen (PWM) will be used to stimulate T and B lymphocytes; lipopolysaccharide (LPS) will be used to stimulate B lymphocytes. Cultures will be pulsed with $^{3}$H-thymidine following standard protocols. Preliminary experiments will be done to optimize concentrations and pulse times.
3. *Cytokine (Interleukin) production.* Activated lymphocytes produce bioactive peptides, collectively called cytokines or interleukins (IL). IL-2 and IL-4 produced by activated T lymphocytes regulate other T and B cells. IL-2 is made by the $T_H1$ subset; IL-4 by the $T_H2$ cells. IL-6, a major cytokine in inflammation, acts both on endocrine (pituitary) and immune cells. These interleukins will be measured in the culture medium of unstimulated and mitogen and antigen stimulated blood cells by commercially available ELISA kits.
4. *Surface differentiation antigens.* Subpopulations and maturational stages of lymphocytes can be distinguished by monoclonal antibodies to cell surface antigens. Exercise has been reported to change the composition of the blood in respect to

these subpopulations of cells, possibly by altered cell trafficking caused by changes in blood circulation. We will use a panel of monoclonal antibodies to quantify subpopulations of cells and to examine expression of certain adhesion molecules (selectins and integrins) important in cell trafficking.

Analysis will be performed on unseparated cells in whole peripheral blood.[46] Briefly, l00 ml whole heparinized blood will be incubated with each antibody followed by a fluorescent second antibody. Red blood cells will be lysed, the white blood cells fixed with l% parafarmoldehyde and the samples analyzed by flow cytometry which will be used to quantify stained cells and determine percentage composition of the blood.

***Magnetic Resonance Imaging (MRI)*** MR images will be collected at 0, 3, 6 months using our clinical MRI 0.5-Tesla super conduction magnet (Picker International Inc., Highland Heights, OH). Analysis of the cross-sectional area (CSA) muscle sizes of both thighs and upper arms will be determined from the MRI scans using a gradient echo technique which allows the greatest delineation and distinction between muscles and has been shown to be more sensitive than CT scans for determining muscle size changes. Appropriate internal controls and phantom evaluations will be obtained. Seventeen contiguous transaxial images 1 cm thick will be obtained between standard anatomical landmarks. All MR images will be ported to a Macintosh computer for calculation of muscle CSA using a modified version of the Image software package available at no cost from the National Institutes of Health, Research Services Branch.

***Militarily Relevant Task Performances.*** The following militarily relevant task performance tests will be administered at 0 and 6 months of the investigation at Penn State by the USARIEM: Occupational Physiology Division.

*Backpack Load Carriage.* Subjects will transport a 75 lb. load using standard external frame Army backpacks (ALICE Pack) as rapidly as possible a distance of two-miles over a paved, flat surface (road or track). Time will be recorded as the measure of performance. The 75 lbs. approximates the maximal acceptable load for approach march conditions, e.g. prolonged road march operations where contact with the enemy is unlikely [(47)]. The ability to carry backpack loads over long distances is a uniquely relevant military task which is required of all soldiers.

*Maximal Lifting Capacity.* The maximal amount of weight that can be lifted in a box with side handles from the floor to 132 cm (height of the bed of a 2 1/2 ton truck) will be determined. Following instructions on proper lifting technique and appropriate warm-up, subjects will lift the incrementally weighted boxes beginning with a light weigh until the subject can not safely complete a lift. After a failed attempt, weight will be removed to yield a load between the failed load and the highest successful lift. The 1 RM box lift will thus be measured as to the nearest 1.0 kg.[48].

*Repetitive Lifting Capacity.* Repetitive lifting capacity will be measured using a 45 lb. box and 2 platforms placed 8 feet apart at the height of the back of an Army truck (height 76 cm). Subjects will lift the weighted box from the floor, turn to their right or left, and place the box on a other table and walk over to the other platform to place another box on it.. Technicians return the boxes to the floor. Subjects will complete as many lifts as possible within 10 min. Repetitive lifting is another very common physical task found in a number of military occupational specialties [49].

*Army Physical Fitness Test.* Each subject will perform the Army's physical fitness test which consists of the maximal number of push-ups that can be performed in 2 minutes, the maximum number of sit-ups that can be performed in 2 minutes and time for a 2 mile run on a measured track [36]. A comparison will be made between the results of this standard Army test and other physical tests administered in this study.

*Health and Dietary Monitoring.* Each subject's health status and nutritional intake are of great concern to us in order for each women to continue with their training programs and meet the caloric expenditures of advanced training. We will monitor health status by having our physicians available for appointments and will collect clinical data concerning illness. Appropriate health care and subject monitoring will be used to avoid any extended absences from training. Computer analyses of intake diaries and counseling by our nutritional staff of registered dietitians will occur prior to and throughout the study to make sure that the dietary intakes can support the nutritional demands and caloric expenditure of training.

***Time/Work Hours.*** The following information is provided in order for the reader to gain a understanding of the amount of time and number of personnel involved with a physical training study of this magnitude.

**Logged Total Hours For Investigation Over the First Year**

1. Total Training Hours (research assistant trainers and testing assistants):
   **9050** hrs
   - combined trainers and testing assistants...
     **70** personnel

2. Total Supervision and Testing Hours
   plus Hours for Training Supervisors (organizational meetings and supervision):
   **5750** hrs
   - **8** training supervisors
   - **5** overall supervisors
     (includes areas of team leader, training, nutrition, assistant supervising)
     total of **13** personnel

3. Total Hours for Blood work (collection, processing, and assay analyses):
   **2500** hrs
   - **7** personnel for complete immune analyses
     **5** personnel for RIA, Bio-active analyses, clinical chemistries

4. Total Hours Subjects for Supervised Training and Testing:
   **11085** hrs
   - includes 48 subjects who remained in study until T2
   - total 37 subjects fully completed study

5. Performance Testing in Men
   **297** hours to test 35 men
   **6** personnel

**Grand Total:**

≈ 28,682 **contact hours.**
≈ 101 total personnel plus investigators

***Statistical Analyses.*** We have developed a computer data base for the investigation. We will use common descriptive statistics to describe the data sets. In addition, a wide range of multivariate statistical analyses will be used to determine group differences, main effects, interactions, and relationships between variables. When appropriate, non-parametric analyses will also be used. Significance in this investigation will be set at $p \leq 0.05$.

## RESULTS

Since this is the annual report for the first phase of the study, incomplete data sets are available for formal analyses on our longitudinal questions related to training effects. We will try to give the reader of this document some preliminary data which may provide some insights and examples of our data set and collection. into our data collection and experimental process by providing some preliminary data where possible. We will also overview the milestones or our first 4 quarters.

### QUARTERLY OVERVIEW ON RESEARCH PROGRESS

### 1ST QUARTER 1995/96

COMMENTS ON ADMINISTRATIVE AND LOGISTICAL MATTERS

This first quarter report signifies the initial start-up phase of the research protocol. Over this time period we have made significant progress in the preparations for the study (e.g., pilot testing of protocols, initial phase subject recruitment and screening etc.). This phase involved the pilot testing, implementation of training protocols, initial testing, and refinements of a chain of command for the study. The experimental chain of command includes communication with the principal investigators, physicians, athletic trainers, study coordinators, training coordinators, nutritionists, training supervisors, and personal trainers for each subject. From experience we have found that a formal structure provides a communication framework for: 1) assuring maximal subject longevity through preventive medical intervention, providing extrinsic motivation, and reducing potential socioeconomic conflicts; 2) insuring continual maintenance of training schedules before and after testing by monitoring training sessions and trainers; 3) efficient scheduling for testing that accommodated study personnel, collateral laboratory, and subject schedules within the specific scientific aims for testing; 4) minimizing unforeseen inadequacies in personnel and

subjects that may sacrifice scientific and logistical integrity by personnel substitution and training; and 5) efficient data collection and analyses. Furthermore, this chain of command is continually striving to further enhance efficiency by using work objectives, subject feedback, and critical unit review as the standard for implementation and attainment of training and testing goals. Thus, the first quarter involved the many start-up activities in logistical organization and structure in addition to the scientific aspects of the study.

SCIENTIFIC PROGRESS (Per Statement Work)

*A. Task - Pilot test all experimental variables and equipment.* We accomplished this goal in the first quarter of the investigation. In the first quarter all experimental tests were pilot tested and test re-test reliabilities were established. All this work was accomplished in August prior to pre-training (T-1) testing of women in the first phase of the investigation.

*B. Task - Recruit, gain informed consent, medically screen, familiarize, and pre-test women.* We recruited 52 women for initial briefing and screening. After screening and testing 45 women started in phase one of the investigation. We initiated their testing and started their training programs.

*C. Task - Match, balance and randomize women into subject groups* - We have placed subjects in training groups in the first phase of the study. We continued to work on the subject recruitment and matching process.

*D. Task - Perform training familiarization.* - This was accomplished this with our first group of test subjects. All subjects individually received a complete program of familiarization for the training programs and test protocols they were assigned.

*E. Task - Initiate supervised physical training programs* - This was accomplished with our first group of women volunteers for the study. Individually supervised training programs were initiated for the women in this first phase of the investigation.

*F. Task - Perform data collection* - Data collection was initiated with pre-training testing (T-1) in this first quarter. The future testing timelines in conjunction with training program demands were scheduled for mid-training, 3 months (T-2) and after 6 months of training (T-3).

*G. Task - Perform biochemical and immunological assays* - All of the radioimmunoassays (RIA), biochemical assays, and bioassays (BA) had preliminary workups in the laboratory performed. Since we routinely perform each of these assays each assay was ready for analysis of blood samples. Radioimmunoassay for samples for each subject will be analyzed in one batch to eliminate interassay variation (after T-3). Clinical chemistries (e.g., blood lactates) are underway after T-1 testing. For the immunological assays, two primary tasks were achieved in the first quarter including preliminary work necessary to initiate data collection and the collection of baseline data for the first series of subjects. Preliminary work included the optimization of mitogen concentrations and incubation times for the lymphocyte proliferation assay, pilot work to establish a procedure and antibody concentrations for labeling of whole blood leukocytes, and establishment of whole blood and cultured lymphocytes procedures to measure cytokine production. The procedures will be assessed after the first series of samples are collected and analyzed, and improvements will be implemented if necessary. Analysis of blood samples collected was performed for the parameters described above. At this point, some preliminary analysis of the data has been completed for the first group of subjects at the onset of the investigation. Lymphocyte proliferative response to mitogen stimulation, an index of the ability of the immune system to respond to a challenge was depressed in some of mitogen conditions following the exercise test, the lymphocyte responsiveness to mitogen stimulation . Additionally, samples of whole blood and isolated lymphocyte cultures were stimulated with a mitogen, and plasma and culture supernatant aliquots were collected for analysis of interleukins (IL) IL-2, IL-4, IL-6, and IL-10. Cell labeling of leukocytes in whole peripheral blood was performed using fluorescently labeled monoclonal antibodies to identify the proportions of cells in the circulation that are T helper lymphocytes (CD3+CD4+CD8-), T cytotoxic lymphocytes(CD3+CD4-CD8+), B cells (CD3-CD19+), NK cells (CD3-CD16+56+), naive (CD45RA+) or memory (CD45RO+) lymphocytes, and activated lymphocytes (CD25+ or CD69+). Additional labeling was done to characterize the adhesion molecules on the surface of these cells to assess the mechanism controlling changes in lymphocyte subset proportions that occur in response to exercise stress. Cell labeling preparations were evaluated using flow cytometry. Preliminary data suggest that there was a dramatic exercise-induced increase in the proportion of NK cells, a modest increase in naive lymphocytes, and modest decreases in T helper and B cells. Further, there was a shift in the surface adhesion molecules such that more cells expressed very late antigen-4 (VLA-4) integrin, and fewer cells expressed L-selectin.

*H. Task - Perform MRI image scans of upper and lower limb musculature* - This has been completed for T-1 testing. MRI scans have been completed on the initial group of test subjects. Initial analyses are in progress.

*I. Task - Perform electromyographical and strength test evaluations-* This has been completed for T-1 testing. EMG and strength tests have been completed on the initial group of test subjects that will start the training study. Initial analyses are in progress.

*J. Task - Coordinate with the United States Army Research Institute's Occupational Physiology Division military relevant physical performance task tests at Penn State.* - We accomplished this. The PI visited USARIEM prior to the study and worked with Dr. Harman and instituted appropriate protocols consistent with USARIEM tasks related to box lift tasks and ruck sack carry task. Differences that exist relate to test improvement and equipment. Military relevant task testing including the APRT have been completed on the initial group of test subjects.

*K. Task - Develop computer data base management scheme and perform data entry and analyses over the course of the experimental period.* - This is in progress and a data base software program has been purchased and initial set-ups have been achieved. We have developed a data base system using the SPSS statistical analysis system for the data generated in this study.

*L. Task - Utilize phase one weight room data to develop optimal strategies for program design of "field training" resistance program.* This task is premature in year one of the investigation.

*M. Task - Analyze data set and provide appropriate reports, physical training recommendations, and scientific publications on physical training of women* - We will provide the progress reports on the study. Scientific publications related to the intact project are premature in year one of the study. However, we will be looking to develop cross-sectional results and appropriate abstracts and manuscripts in year one.

**2nd QUARTER 1995/96**

COMMENTS ON ADMINISTRATIVE AND LOGISTICAL MATTERS

We made significant progress in the 2nd quarter in that T-2 testing was completed and subject attrition (due to non-study causes) was under the expected 33% reported for training studies in the literature. We are continuing to work on a variety of data sets (e.g., cross-sectional) within the context of the total experimental design as the project continues. This report signifies the accomplishments in the 2nd quarter of the investigation for year one. Implementation of training protocols and testing increased in efficiency with continuing refinements of a chain of command. Thus, the second quarter involved the continuation of the training protocols and continued testing and laboratory analyses.

SCIENTIFIC PROGRESS (Per Statement of Work)

*A. Task - Pilot test all experimental variables and equipment.* - We accomplished this goal in the first quarter of the investigation.

B. *Task - Recruit, gain informed consent, medically screen, familiarize, and pre-test women.*- We are continued to work with the group of women for the first phase of the study that we recruited in the first quarter. 36 women are still in the study after the T-2 testing. All subject attrition has been due to non-study reasons (e.g., change in job time constraints, etc.).

*C. Task - Match, balance and randomize women into subject groups* - We already placed subjects in training groups in the first phase of the study. We continued to work on the subject recruitment process and matching to gain the appropriate n size and characteristics for each group.

*D. Task - Perform training familiarization* - We have accomplished this with our first group of test subjects in the first quarter of the study.

*E. Task - Initiate supervised physical training programs* - This was accomplished with our first group of women who volunteered for the investigation in the 1st quarter of the study and training continued.

*F. Task - Perform data collection* - We completed T-2 (i.e., mid-training time point at 3 months of training) data collection with our first group of test subjects in phase one of the study.

*G. Task -Perform biochemical and immunological assays* - Radioimmunoassays for samples for each subject will be analyzed in one batch to eliminate interassay variation. All RIAs are ready for up coming analyses with all assays up and running in the laboratory. Clinical chemistries (e.g., blood lactates) were underway after T-1 testing. BA are up and running an preliminary workups have been accomplished. For the immunological assays, the primary tasks achieved in the second quarter were the preparation and analysis of blood samples collected at the training program midpoint and the continued analysis of samples and data collected during the previous quarter at the initiation of training. As before, the three primary areas of data collection for immunological assessment were mitogen stimulation, characterization of the leukocytes in the circulation by labeling surface proteins with monoclonal antibodies, and analysis of cytokines produced by circulating leukocytes. No changes were made in the mitogen stimulation procedure and these assays are currently in the process of being completed. In addition to the cell labeling identifications made during the first testing session, the VLA-4 integrin and L-selectin antibodies were used in combination with T and NK cell markers so that more information regarding the mechanism of lymphocyte trafficking changes induced by exercise may be obtained. Samples for cytokine analysis were collected as before. Additional work was performed to validate the presence of high IL-6 and IL-10 concentrations in the culture supernatants collected during the first quarter. Many of the samples collected for the analysis of cytokines during the first round of data collection for the first group of subjects were analyzed using ELISA kits.

*H. Task - Perform MRI image scans of upper and lower limb musculature* - This has been completed for T-2 testing. MRI scans have been completed on the initial group of test subjects that have continued in the study. Initial analyses were still in progress.

*I. Task - Perform electromyographical and strength test evaluations* - This was completed for T-2 testing. EMG and strength tests have been completed on the initial group of test subjects that have continued in the study. Initial analyses are still in progress.

*J. Task - Coordinate with the United States Army Research Institute's Occupational Physiology Division military relevant physical performance task tests at Penn State.* - We accomplished this in the first quarter of the study and T-2 military relevant task testing were completed.

*K. Task - Develop computer data base management scheme and perform data entry and analyses over the course of the experimental period.* - Again, this continued to be in

progress. The data base software program set-ups have been achieved. We are using the SPSS statistical analysis system for the data management in this study.

*L. Task - Utilize phase one weight room data to develop optimal strategies for program design of "field training" resistance program.* This task is premature in year one of the investigation.

*M. Task - Analyze data set and provide appropriate reports, physical training recommendations, and scientific publications on physical training of women* - We provided the progress reports on the study. Scientific publications related to the intact project are premature in year one of the study. However, we will be looking to develop cross-sectional results and appropriate abstracts and manuscripts in year one.

**3RD QUARTER 1995/96**

COMMENTS ON ADMINISTRATIVE AND LOGISTICAL MATTERS

We made significant progress in the 3rd quarter in that T-3 testing was finished and thus the 1st phase (1st year) of our study related to the resistance training of our women has been successfully completed. After initial screening and attrition of women due to non-study reasons, only one subject had to drop from the study (due to an accidental injury that was non-study related) between T-2 to T-3. We have started to established a central database and have begun data entry and preliminary data analysis on cross-sectional results.

DESCRIBE SCIENTIFIC PROGRESS (per Statement of Work)

*A. Task - Pilot test all experimental variables and equipment.* This was all completed in the 1st quarter of the investigation.

*A. Task - Pilot test all experimental variables and equipment.* We accomplished this goal in the first quarter of the investigation. In the first quarter all experimental tests were pilot tested and test re-test reliabilities were established. All this work was accomplished in August prior to pre-training (T-1) testing of women in the first phase of the investigation.

*B. Task - Recruit, gain informed consent, medically screen, familiarize, and pre-test women and men* - We have recruited an initial group of men and started testing (1 RMs, Army

physical fitness test, anthropometry, repetitive boxlift, 2 mile rucksack carry, squat endurance). These men will serve as controls for performance tests in women. We have recruited a pool of 160 women subjects from which to screen for subjects as we get ready for year 2 of the study.

*C. Task - Match, balance and randomize women into subject groups* - We have placed subjects in training groups in the first phase of the study. We continued to work on the subject recruitment and matching process.

*D. Task - Perform training familiarization.* - This was accomplished this with our first group of test subjects. All subjects individually received a complete program of familiarization for the training programs and test protocols they were assigned.

*E. Task - Initiate supervised physical training programs* - We completed the periodized training programs for each of the experimental groups of women participating in the four different resistance training programs and initiated T3 (post-6 months of training) testing for all of the women. We have completed 37 women in the 4 resistance training groups.

*F. Task - Perform data collection* - We completed T-3 (i.e., final time point after 6 months of training) data collection with the first group of women test subjects in phase one of the study. We filled 4 of the groups with the following "n" sizes. Total body strength power n= 11 ; Upper Body Strength/Power n = 8 ; Total Body Hypertrophy n= 10 ; Upper Body Hypertrophy n= 8.

*G. Task - Perform biochemical and immunological assays* - RIAs for total and free testosterone, cortisol, growth hormone, prolactin, and insulin-like growth-factor (IGF-1) are currently being assayed. In the third quarter, the work done included the continued analysis of data from T-1 and T-2 and now T-3. Analysis of data and biological samples included the following activities: 1) scintillation counting to determine the incorporation of tritiated thymidine during the proliferation of lymphocytes; 2) entering scintillation data into a spreadsheet for analysis and editing of the data; 3) measurement of the IL-6 and IL-10 cytokine concentrations in culture supernatants and plasma using ELISA's; 4) preliminary work to establish a technique to measure IL-2 in the form of a bioassay, and comparison of this technique to the ELISA to make sure that the most sensitive and meaningful assay is being done; 5) reduction of cell labeling data collected using flow cytometry , a lengthy process done one stain at a time for 14 to 15 different stains prepared from each blood

sample; and 6) preparation of the DNA plasmids and cDNA probes necessary for quantifying perforin RNA message, a protein used by cytotoxic cells that serves as an indication of the cytolytic activity of NK and CD8+ cells. Preparation and analysis of samples collected from the subjects who completed the training were consistent with the first two bleedings and included the following procedures: 1) the lymphocyte proliferative response to mitogen stimulation; 2) labeling of peripheral blood leukocytes with monoclonal antibodies for the identification of lymphocyte subset phenotypes, adhesion molecules, and activation markers; 3) stimulation of whole blood and isolated lymphocyte cultures for cytokine production; and 4) preparation of nuclear materials for subsequent analysis of the RNA signal for perforin.

*H. Task - Perform MRI image scans of upper and lower limb musculature* - Completed tracings (for the assessment of muscle cross-sectional areas) have been completed for all subjects at all time points on the Microtek imaging system.

*I. Task - Perform electromyographical and strength test evaluations-* EMG data has been processed and downloaded for all subjects for all time points (T1, T2, T3). Integration and analyses are underway for the first year's data collection.

*J. Task - Coordinate with the United States Army Research Institute's Occupational Physiology Division military relevant physical performance task tests at Penn State.* - Completed for investigation.

*K. Task - Develop computer data base management scheme and perform data entry and analyses over the course of the experimental period.* - Data entry continues in an ongoing part of the study. F. Strength and physical performance - 1 repetition maximum testing (squat, bench press, high pull, boxlifts), Army physical fitness test, anthropometry, repetitive boxlift, 2 mile rucksack carry and squat endurance data has collected and entered into the data base.

*L. Task - Utilize phase one weight room data to develop optimal strategies for program design of "field training" resistance program.* This task is premature in year one of the investigation.

*M. Task - Analyze data set and provide appropriate reports, physical training recommendations, and scientific publications on physical training of women* - We will provide

the progress reports on the study. Scientific publications related to the intact project are premature in year one of the study. However, we will be looking to develop cross-sectional results and appropriate abstracts and manuscripts in year one.

**4TH QUARTER 1995/96**

COMMENTS ON ADMINISTRATIVE AND LOGISTICAL MATTERS

We have made significant progress in the 4rd quarter in that we have started to test more men for control purposes and screened 200 women volunteers for year 2 of the project. This report signifies the accomplishments in the 4rd quarter for year one. Our primary goals were related to recruitment of women for year 2 and testing of men for our control group data set for the strength/power gender comparisons. We have continued our refinements of a chain of command.

DESCRIBE SCIENTIFIC PROGRESS (Per Statement of Work)

*A. Task - Pilot test all experimental variables and equipment.* This was all completed in the 1st quarter of the investigation.

*A. Task - Pilot test all experimental variables and equipment.* We accomplished this goal in the first quarter of the investigation. In the first quarter all experimental tests were pilot tested and test re-test reliabilities were established. All this work was accomplished in August prior to pre-training (T-1) testing of women in the first phase of the investigation.

*B. Task - Recruit, gain informed consent, medically screen, familiarize, and pre-test women and men.* We recruited, gained informed consent and familiarized 35 men with the strength, power, military relevant task performance testing. We now recruited 200 women to screen for the 1st quarter of the second year.

*C. Task - Match, balance and randomize women into subject groups* - We have placed all of the men into the control male group for gender comparisons.

*D. Task - Perform training familiarization.* - No training familiarization was needed for the men as they would perform no training in this study.

*E. Task - Initiate supervised physical training programs* - We tested only men who were not involved in any of the training programs in the design of this study.

*F. Task - Perform data collection* - We recruited, gained informed consent and familiarized 35 men with the strength, power, military relevant task performance testing. We completed testing on all of these men. (35 completed out of a targeted 100 men for the gender control group for strength/power comparisons.

*G. Task - Perform biochemical and immunological assays* - Continued RIAs for total and free testosterone, cortisol, growth hormone, prolactin, and insulin-like growth-factor (IGF-1) are currently being processed. Initiated bioactive GH analyses. Progress relating to the immunological portion of this investigation was made in the areas of blood sample preparation and analysis, and data reduction and analysis. Preparation of blood samples from the final subjects of phase 1 (t3) and the first 27 subjects of phase 2 (t4) was performed for detection of lymphocyte surface markers in whole peripheral blood, lymphocyte proliferative response to mitogen stimulation in cultured lymphocytes, and for subsequent cytokine determinations and quantification of perforin mRNA message using polymerase chain reaction (PCR). Data from flow cytometric analysis of lymphocyte cell surface markers was analyzed using Elite software (t1 and t2) and the proportions of cells bearing each marker was determined. These proportions were combined with the total white cell count and differential data from the complete blood count data to calculate the concentrations of all cell populations. Preliminary statistical analyses were performed and it was found that the 6 x 10 repetition maximum squat test induced extreme leukocytosis. The most pronounced leukocyte increases were found for neutrophils, NK (> 300%) and CD8+ (> 60%) lymphocytes. Despite decreases in the proportion of CD4+ and B lymphocytes, the absolute concentration of these cell types increased. It was apparent that the T and B lymphocytes were recruited to the circulation predominantly from peripheral stores due to the greater increase in lymphocytes bearing naive cell markers as opposed to those bearing memory cell markers. The incorporation of tritiated thymidine during mitogen stimulation assays for t2 and t3 was quantified using a beta scintillation counter and data were put into spreadsheet format for further analysis. Quantification of IL-2 in selected serum and culture supernatants using a bioassay was begun during this quarter also. Data from these latter analyses have not been statistically analyzed at this time.

*H. Task - Perform MRI image scans of upper and lower limb musculature* - Continued to work on MRI tracings (for the assessment of muscle cross-sectional areas). Have

completed single cross-sections for arm and thigh data from women who completed the training programs and are now starting analysis of other sections for the thigh and arm musculature.

*I. Task - Perform electromyographical and strength test evaluations-* EMG data has been processed and downloaded for all subjects for all time points (T1, T2, T3). Have developed working integration programs and initial analyses of training data is underway.

*J. Task - Coordinate with the United States Army Research Institute's Occupational Physiology Division military relevant physical performance task tests at Penn State. -* Completed in quarter one of year one.

*K. Task - Develop computer data base management scheme and perform data entry and analyses over the course of the experimental period.* - Data entry continues in an ongoing part of the study. 1 repetition maximum testing (squat, bench press, high pull, boxlift), Army physical fitness test, anthropometry, repetitive boxlift, 2 mile rucksack carry and squat endurance data has been characterized statistically for use in matching process for year 2.

*L. Task - Utilize phase one weight room data to develop optimal strategies for program design of "field training" resistance program.* This task is premature in year one of the investigation.

*M. Task - Analyze data set and provide appropriate reports, physical training recommendations, and scientific publications on physical training of women* - We will provide the progress reports on the study. Scientific publications related to the intact project's longitudinal questions are premature in year one of the study. However, we are working on cross-sectional data analyses where appropriate. Presented data on cross-sectional responses of selected immune factors at national meeting of the National Strength and Conditioning Association in Atlanta, GA (see attached Appendix)

**Ranges for Some of the Test Variables Collected in Year One**

The following tables for each of the testing time points are provided to give the reader some insights into the total group response in some of the performance tests.

**T-1 Testing Time Point**

| Variable | Mean | SD | SE | Minimum Value | Maximum Value |
|---|---|---|---|---|---|
| age (yrs) | 22.35 | 3.51 | 12.31 | 18 | 32 |
| bench (kg) | 33.90 | 7.47 | 55.83 | 21.80 | 58.45 |
| boxlift (kg) | 28.44 | 5.22 | 27.23 | 20.60 | 48.20 |
| high pull (kg) | 34.24 | 5.41 | 29.23 | 26.40 | 54.30 |
| pushups (#) | 20.82 | 13.51 | 182.47 | 0 | 55 |
| rep box lift (rep. #) | 91.96 | 24.27 | 588.84 | 20 | 159 |
| squat endurance test (#) | 23.48 | 16.98 | 288.47 | 0 | 95 |
| squat (kg) | 52.09 | 12.30 | 151.17 | 31.65 | 87.60 |
| situps (#) | 40.43 | 17.21 | 296.09 | 5 | 73 |
| two mile run time (min:sec) | 18.90 | 3.42 | 704.28 | 31:41 | 13:50 |
| two mile ruck sack (min:sec) | 32.23 | 5.42 | 1764.64 | 44:48 | 21:47 |
| body mass (kg) | 62.23 | 9.77 | 95.41 | 42.71 | 105.61 |

**T-2 Testing Time Point**

| Variable | Mean | SD | SE | Minimum Value | Maximum Value |
|---|---|---|---|---|---|
| bench (kg) | 41.06 | 8.23 | 67.69 | 26.40 | 66.10 |
| box lift (kg) | 33.29 | 5.78 | 33.45 | 23 | 52.75 |
| high pull (kg) | 36.57 | 6.55 | 42.86 | 21.85 | 56.60 |
| rep box lift (#) | 110.95 | 20.64 | 426.00 | 61 | 174 |
| squat endurance test (kg) | 35.62 | 20.23 | 409.35 | 7 | 115 |
| squat (kg) | 60.98 | 12.91 | 166.61 | 40.25 | 94.85 |
| body mass (kg) | 61.86 | 8.13 | 66.04 | 41.27 | 80.45 |

**T-3 Testing Time Point**

| Variable | Mean | SD | SE | Minimum Value | Maximum Value |
|---|---|---|---|---|---|
| bench (kg) | 46.16 | 7.82 | 61.21 | 31.75 | 69.45 |
| box lift (kg) | 36.66 | 6.23 | 38.86 | 26.30 | 55.15 |
| squat endurance test (#) | 42.21 | 19.39 | 375.87 | 15.00 | 111.00 |
| squat (kg) | 69.03 | 14.65 | 214.48 | 45.20 | 107.62 |
| situps (#) | 64.55 | 14.13 | 199.69 | 38 | 93.00 |
| two mile run time (min:sec) | 17.78 | 2.39 | 5.71 | 23.41 | 14:17 |
| two mile ruck sack (min:sec) | 29.40 | 3.82 | 876.63 | 24.00 | 35:47 |
| Body Mass (kg) | 63.50 | 7.82 | 135.87 | 42.36 | 80.00 |

## CONCLUSIONS

At this point in the study no conclusions can be drawn as to the outcome of the longitudinal aspects of the study. We have seen improvement with training. Our data on acute immune function and its relationship to strength has shown that the stronger women are capable of performing much greater amounts of work which results in an acute immuno-suppression. Thus, it is possible that enhanced strength capabilities with training may also enhance the probability that acute immuno suppression can occur and care must be taken within the first 2 to 4 hours after the workout not to come in contact with pathogens.

# REFERENCES

## BIBLIOGRAPHY


1. Sharp, M.A. Physical fitness and occupational performance of women in the U.S. Army. *Phys. Fitness Occup. Perf. Women*, 4(2):80-92, 1994.

2. Sharp, M. A., and Vogel, J.A. 1992. Maximal lifting strength in military personnel. IN: Advances in Industrial Ergonomics and Safety IV. (S. Kumar, ed.). 1992, 1261-1266.

3. Fleck, S.J. and W.J. Kraemer, *Designing Resistance Training Programs*. Human Kinetic Publishers, Champaign, IL. (264 pages), 1987.

4. Baechle, T.R. Women in resistance training. *Clin. Sports Med.*, 3(4):791-808, 1984.

5. Cureton, K.J., Collins, M.A., Hill, D.W., and McElhannon, F.M. Muscle hypertrophy in men and women. *Med. Sci. Sports Exerc.*, 20(4):338-344, 1988.

6. Jetté, M. and Sidney, K. Variation of responses to heavy resistance training in women. *Clin. Sports Med.*, 2:75-81, 1990.

7. Westerlind, K.C., Byrnes, W.C., Freedson, P.S., Katch, F.I. Exercise and serum androgens in women. *Phys. Sportsmed.*, 15(5):87-94, 1987.

8. Myers, D.C., Gebhardt, D.L., Crump, C.E., and Fleishman, E.A. Validation of the military entrance physical strength capacity test. Technical Report 610, US Army Research Institute of Behavioral and Social Sciences, January 1984.

9. Kraemer, W.J. and L.P. Koziris. Muscle strength training: Techniques and considerations. *Physical Therapy Practice*, 2(1):54-68, 1992.

10. Kraemer, W.J., J.A. Vogel, J.F. Patton, J.E. Dziados, and K.L. Reynolds. The effects of various physical training programs on short duration high intensity load bearing performance and the Army physical fitness test. *USARIEM Technical Report,* 30/87 August, 1987.

11. Häkkinen, K., Pakarinen, A., Kyröläinen, H., Cheng, S., Kim, D.H., and Komi, P.V. Neuromuscular adaptations and serum hormones in females during prolonged power training. *Int. J. Sports Med.*, 11:91-98, 1990.

12. Kraemer, W.J. and L.P. Koziris. Olympic Lifting and Power Lifting. Physiology and Nutrition for Competitive Sport, D.R. Lamb, H.G. Knuttgen, and R. Murray, (Eds), Cooper Publishing Group, Carmel, IN, Cooper 1994, p. 16-54.

13. Alway, S.E., Grumbt, W.H., Gonyea, W.J., and Stray-Gundersen, J. Contrasts in muscle and myofibers of elite male and female bodybuilders. *J. Appl. Physiol.*, 67(1):24-31, 1989.

14. Alway, S.E., Stray-Gundersen, J., Grumbt, W.H., and Gonyea, W.J. Muscle cross-sectional area and torque in resistance-trained subjects. *Eur. J. Appl. Physiol.,* 60:86-90, 1990.

15. Kraemer, W.J., B.J. Noble, B.W. Culver, and M.J. Clark. Physiologic responses to heavy-resistance exercise with very short rest periods. *International Journal of Sports Medicine,* 8:247-252, 1987.

16. Staron, R.S. , D.L. Karapondo, W.J. Kraemer, A.C. Fry, S.E. Gordon, J.E. Falkel, F.C. Hagerman, and R.S. Hikida. Skeletal muscle adaptations during the early phase of heavy-resistance training in men and women. *Journal of Applied Physiology* 76(3):1247-1255, 1994.

17. Staron, R.S., Leonardi, M.J., Karapondo, D.L., Malicky, E.S., Falkel, J.E., Hagerman, F.C., and Hikida, R.S. Strength and skeletal muscle adaptations in heavy-resistance-trained women after detraining and retraining. *J. Appl. Physiol.,* 70(2):631-640, 1991.

18. Kraemer, W.J. Chapter 9C. Endocrine responses and adaptations to strength training. The Encyclopaedia of Sports Medicine: Strength and Power. P.V. Komi (Ed.) Blackwell Scientific Pub. London, pp 291-304, 1992.

19. Kraemer, W.J., L. Marchitelli, D. McCurry, R. Mello, J.E. Dziados, E. Harman, P. Frykman, S.E. Gordon and S.J. Fleck. Hormonal and growth factor responses to heavy resistance exercise. *Journal of Applied Physiology*, 69(4):1442-1450, 1990.

20. Kraemer, W.J., S.E. Gordon, S.J. Fleck, L.J. Marchitelli, R. Mello, J.E. Dziados, K. Friedl, E. Harman, C. Maresh, and A. C. Fry. Endogenous anabolic hormonal and growth factor responses to heavy resistance exercise in males and females. *International Journal of Sports Medicine,* 12(2):228-235, 1991.

21. Kraemer, W.J., S.J. Fleck, J.E. Dziados, E.A. Harman, L.J. Marchitelli, S.E. Gordon, R. Mello, P.N. Frykman, L.P. Koziris, and N.T. Triplett. Changes in hormonal concentrations following different heavy resistance exercise protocols in women. *Journal of Applied Physiology,* 75(2):594-604, 1993.

22. Kraemer, W.J. Endocrine responses to resistance exercise. *Medicine and Science in Sports and Exercise,* 20 (suppl):S152-S157, 1988.

23. Häkkinen, K., Pakarinen, A., Komi, P.V., Ryushi, T., and Kauhanen, H. Neuromuscular adaptations and hormone balance in strength athletes, physically active males and females during intensive strength training. *XII International Congress of Biomechanics*, 1989.

24. Häkkinen, K. Neuromuscular responses in male and female athletes to one strength training session. *Sports, Med., Health,* 457-462, 1990.

25. Lewis, U.L. Growth Hormone: What is it and what does it do? TEM 3(4):117-121, 1992.

26. Ellis, S., M.A. Vodian, and R. E. Grindeland. Studies on the bioassayable growth hormone-like activity of plasma. *Recent Progress in Hormone Research* 34:213-238, 1978.

27. Luthman, M., I. Jonsdottir, B. Skoog, I.-L. Wivall, P. Roos, and S. Werner. Monoclonal antibodies reveal circulating growth hormone of high molecular weight not detectable by conventional assays. *Acta Endocrinologica* 123:317-325, 1990.

28. Stolar, M.W., and G. Baumann. Big growth hormone forms in human plasma: Immunochemical evidence for their pituitary origin. *Metabolism* 35(1):75-77, 1986.

29. Moore, R.J., K.E. Friedl, T.R. Kramer, L.E. Martinez-Lopez, R.W. Hoyt, R.E. Tulley, J.P. DeLany, E.W. Askew, and J.A. Vogel. 1992. Changes in soldier nutritional status and immune function during the Ranger training course. Technical Report No. T13-92. U.S. Army Research Institute of Environmental Medicine. Natick, Massachusetts.

30. Cohen, J.H., L. Danel, G. Cordier, S. Suez, and J-P Revillard. 1983. Sex steroid receptors in peripheral T cells: Absence of androgen receptors and restriction of estrogen receptors to OKT8-positive cells. *J. Immunol.* 131:2767-277l.

31. Kraemer, W.J., S.J. Fleck, R. Callister, M. Shealy, G. Dudley, C.M. Maresh, L. Marchitelli, C. Cruthirds, T. Murray, and J.E. Falkel. Training responses of plasma beta-endorphin, adrenocorticotropin and cortisol. *Medicine and Science in Sports and Exercise,* 21(2):146-153, 1989.

32. DeSouza, M.J., C.M. Maresh, M.S. Maguire, W.J. Kraemer, G.F. Ginter, and K.L. Goetz. Menstrual status and plasma vasopressin, renin activity and aldosterone exercise responses. *Journal of Applied Physiology,* 67:736-743,1989.

33. Häkkinen, K. Changes in physical fitness profile in female volleyball players during the competitive season. *J. Sports Med. Phys. Fitness*, 33(3):223-232, 1993.

34. Stein, M., J.E. Keller, and J.T. Schleifer. Stress and immunomodulation. *J. Immunol.* 135:838-848, 1985.

35. Kraemer, W.J. and S.J. Fleck. Resistance training: Exercise prescription. *The Physician and Sportsmedicine,* 16(6): 69-81, 1988.

36. Field Manual 21-20. Physical Fitness Training. Headquarters, Department of the Army, Sept. 1992.

37. Volpe, S.L., Walberg-Rankin, J., Rodman, K.W., and Sebolt, D.R. The effect of endurance running on training adaptations in women participating in a weightlifting program. *J. Strength and Cond. Res.*, 7(2):101-107, 1993.

38. Fitzgerald, P.I., J. A. Vogel, W. L. Daniel, J.E. Dziados, M.A. Teves, R.P. Mello, and P.J. Reich. The body composition project: A summary report and descriptive data. Natick, MA. USARIEM Technical Report T5/87, 1986.

39. Kraemer, W.J. and T.R. Baechle. Development of a strength training program. Chapter 2 In: Sports Medicine, Second Edition. Allman, F.L. and Ryan, A.J. (Eds), Academic Press. Orlando, FL, pp 113-127, 1989.

40. Wilson, G.J., R. U. Newton, A.J. Murphy, and B.J. Humphries. The optimal training load for the development of dynamic athletic performance. *Med. Sci. Sprots Exerc.* 25:1279-1276, 1991.

41. Newton, R.U., and G.J. Wilson. The kinetics and kinematics of powerful upper body movements: The effect of load. In: *Abstracts of the International Society of Biomechanics XIVth Congress*, Paris, p. 1510, 1993.

42. Kraemer, W.J. Measurement of Strength. *Proceedings of the White House Symposium on Physical Fitness and Sports Medicine.* Weltman, A., Spain, C.G., (Eds), President's Council on Fitness and Sports. Washington, D.C., pp: 35-36, 1983.

43. Kraemer, W.J. and A.C. Fry. Strength testing: Development and evaluation of methodology. In: Physiological Assessment of Human Fitness. P. Maud and C. Foster (Eds) Human Kinetics Pub. Inc., Champaign IL, (In Press).

44. Kraemer, W.J., J.E. Dziados, L.J. Marchitelli, S.E. Gordon, E.A. Harman, R. Mello, S.J. Fleck, P.N. Frykman, and N.T. Triplett. Effects of different heavy-resistance exercise protocols on plasma b-endorphin concentrations. *Journal of Applied Physiology,* 74(1):450-459, 1993.

45. Greenspan, F.S., C.H. Li, M.E. Simpson, and H.S. Evans. Bioassay of hypophyseal growth hormone. *Endocrinology* 45:455-463, 1949.

46. Fleisher, T.A. and G.E. Morti. 1993. Detection of unseparated human lymphocytes by flow cytometry. IN: Current Protocols in Immunology. (J.E. Coligan, A.M. Krwsbeeck, D.M. Margulies, E.M. Shervach, and W. Strober, eds). 1993, 7.9.1-7.I.7.

47. Field Manual 21-18. Foot Marches. Headquarters, Department of the Army, June 1990

48. Teves, MA, Wright, JE, and Vogel JA. Performance on selected candidate screening test procedures before and after Army basic and advanced individual training. *USARIEM Technical Report*, Natick, MA T13-85, 1985).

49. Army Regulation 611-201. Enlisted Career Management Fields and Military Occupational Specialties. Headquarters, Department of the Army, Washington, D.C. 31 October 1989.

# APPENDIX 1

## EAXMPLE WORKOUT PERIODIZATION SHEETS FOR EACH RESISTANCE TRAINING GROUP

**NAME:** _____ **GROUP:** Total Hyper
**TRAINER:** _____

**DAY 1**

| Rest between Sets | | Date | | | Date | | | Date | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 90 sec | Squat | 3 x 12 reps | | | | | | | | |
| 60 sec | Leg Extension | 3 x 12 reps | | | | | | | | |
| 60 sec | Leg Curl | 3 x 12 reps | | | | | | | | |
| 60 sec | DB Incline Press | 3 x 12 reps | | | | | | | | |
| 60 sec | Chest Fly | 3 x 12 reps | | | | | | | | |
| 60 sec | Front Pull Down | 3 x 12 reps | | | | | | | | |
| 30 sec | Upright Row | 3 x 12 reps | | | | | | | | |
| 30 sec | DB Row | 3 x 12 reps | | | | | | | | |
| 60 sec | Rotational Crunch | 3 x 25 reps | | | | | | | | |
| X | Cardiovascular | 25 min | | | | | | | | |

**DAY 2**

| Rest between Sets | | Date | | | Date | | | Date | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 90 sec | Leg Extension | 3 x 12 reps | | | | | | | | |
| 90 sec | Leg Curl | 3 x 12 reps | | | | | | | | |
| 60 sec | Heel Raise | 3 x 12 reps | | | | | | | | |
| 90 sec | Bench Press | 3 x 12 reps | | | | | | | | |
| 90 sec | Seated Row | 3 x 12 reps | | | | | | | | |
| 30 sec | Tri. Push Down | 3 x 12 reps | | | | | | | | |
| 30 sec | EZ Curl | 3 x 12 reps | | | | | | | | |
| 60 sec | Sit-up | 3 x 25 reps | | | | | | | | |
| X | Cardiovascular | 25 min | | | | | | | | |

**DAY 3**

| Rest between Sets | | Date | | | Date | | | Date | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 90 sec | Squat | 3 x 12 reps | | | | | | | | |
| 60 sec | Leg Curl | 3 x 12 reps | | | | | | | | |
| 60 sec | Heel Raise | 3 x 12 reps | | | | | | | | |
| 90 sec | Nar. Bench Press | 3 x 12 reps | | | | | | | | |
| 90 sec | DB Row | 3 x 12 reps | | | | | | | | |
| 30 sec | DB Tricep | 3 x 12 reps | | | | | | | | |
| 30 sec | DB Curl | 3 x 12 reps | | | | | | | | |
| 60 sec | Crunch | 3 x 25 reps | | | | | | | | |
| X | Cardiovascular | 25 min | | | | | | | | |

NAME: _____

GROUP: Total Hyper 42
TRAINER: _____

**DAY 1**

| Rest between Sets | | Date | | | Date | | | Date | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 90 sec | Squat | 3 x 10 reps | | | | | | | | |
| 60 sec | Leg Extension | 3 x 10 reps | | | | | | | | |
| 60 sec | Leg Curl | 3 x 10 reps | | | | | | | | |
| 60 sec | DB Incline Press | 3 x 10 reps | | | | | | | | |
| 60 sec | Chest Fly | 3 x 10 reps | | | | | | | | |
| 60 sec | Front Pull Down | 3 x 10 reps | | | | | | | | |
| 30 sec | Upright Row | 3 x 10 reps | | | | | | | | |
| 30 sec | DB Row | 3 x 10 reps | | | | | | | | |
| 60 sec | Rotational Crunch | 3 x 25 reps | | | | | | | | |
| X | Cardiovascular | 25 min | | | | | | | | |

**DAY 2**

| Rest between Sets | | Date | | | Date | | | Date | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 90 sec | Leg Extension | 3 x 10 reps | | | | | | | | |
| 90 sec | Leg Curl | 3 x 10 reps | | | | | | | | |
| 60 sec | Heel Raise | 3 x 10 reps | | | | | | | | |
| 90 sec | Bench Press | 3 x 10 reps | | | | | | | | |
| 90 sec | Seated Row | 3 x 10 reps | | | | | | | | |
| 30 sec | Tri. Push Down | 3 x 10 reps | | | | | | | | |
| 30 sec | EZ Curl | 3 x 10 reps | | | | | | | | |
| 60 sec | Sit-up | 3 x 25 reps | | | | | | | | |
| X | Cardiovascular | 25 min | | | | | | | | |

**DAY 3**

| Rest between Sets | | Date | | | Date | | | Date | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 90 sec | Squat | 3 x 10 reps | | | | | | | | |
| 60 sec | Leg Curl | 3 x 10 reps | | | | | | | | |
| 60 sec | Heel Raise | 3 x 10 reps | | | | | | | | |
| 90 sec | Nar. Bench Press | 3 x 10 reps | | | | | | | | |
| 90 sec | DB Row | 3 x 10 reps | | | | | | | | |
| 30 sec | DB Tricep | 3 x 10 reps | | | | | | | | |
| 30 sec | DB Curl | 3 x 10 reps | | | | | | | | |
| 60 sec | Crunch | 3 x 25 reps | | | | | | | | |
| X | Cardiovascular | 25 min | | | | | | | | |

NAME: _____

GROUP: Total Hyper 43
TRAINER: _____

**DAY 1**

| Rest between Sets | | Date Time In: Out: | Date Time In: Out: | Date Time In: Out: |
|---|---|---|---|---|
| 60 sec | Squat | 3 x 8 reps | | | |
| 30 sec | Leg Extension | 3 x 8 reps | | | |
| 30 sec | Leg Curl | 3 x 8 reps | | | |
| 60 sec | DB Incline Press | 3 x 8 reps | | | |
| 60 sec | Chest Fly | 3 x 8 reps | | | |
| 60 sec | Front Pull Down | 3 x 8 reps | | | |
| 30 sec | Upright Row | 3 x 8 reps | | | |
| 30 sec | DB Row | 3 x 8 reps | | | |
| 60 sec | Rotational Crunch | 3 x 25 reps | | | |
| X | Cardiovascular | 25 min | | | |

**DAY 2**

| Rest between Sets | | Date Time In: Out: | Date Time In: Out: | Date Time In: Out: |
|---|---|---|---|---|
| 30 sec | Leg Extension | 3 x 8 reps | | | |
| 30 sec | Leg Curl | 3 x 8 reps | | | |
| 30 sec | Heel Raise | 3 x 8 reps | | | |
| 60 sec | Bench Press | 3 x 8 reps | | | |
| 60 sec | Seated Row | 3 x 8 reps | | | |
| 30 sec | Tri. Push Down | 3 x 8 reps | | | |
| 30 sec | EZ Curl | 3 x 8 reps | | | |
| 60 sec | Sit-up | 3 x 25 reps | | | |
| X | Cardiovascular | 25 min | | | |

**DAY 3**

| Rest between Sets | | Date Time In: Out: | Date Time In: Out: | Date Time In: Out: |
|---|---|---|---|---|
| 60 sec | Squat | 3 x 8 reps | | | |
| 30 sec | Leg Curl | 3 x 8 reps | | | |
| 30 sec | Heel Raise | 3 x 8 reps | | | |
| 60 sec | Nar. Bench Press | 3 x 8 reps | | | |
| 30 sec | DB Row | 3 x 8 reps | | | |
| 30 sec | DB Tricep | 3 x 8 reps | | | |
| 30 sec | DB Curl | 3 x 8 reps | | | |
| 60 sec | Crunch | 3 x 25 reps | | | |
| X | Cardiovascular | 25 min | | | |

NAME: _____ GROUP: Total S/P 44
TRAINER: _____

**DAY 1**

| Rest between Sets | | Date | Date | Date |
|---|---|---|---|---|
| DB Clean & Press | 3 x 8 reps | | | |
| Leg Curl | 3 x 8 reps | | | |
| DB Incline Press | 3 x 8 reps | | | |
| Front Pull Down | 3 x 8 reps | | | |
| Squat | 3 x 8 reps | | | |
| Incline Sit-up | 3 x 15 reps | | | |
| Upright Row | 3 x 8 reps | | | |
| DB Row | 3 x 8 reps | | | |
| X Cardiovascular | 25 min | | | |

**DAY 2**

| Rest between Sets | | Date | Date | Date |
|---|---|---|---|---|
| High Pull | 3 x 8 reps | | | |
| Leg Curl | 3 x 8 reps | | | |
| Bench Press | 3 x 8 reps | | | |
| Seated Row | 3 x 8 reps | | | |
| DB Press | 3 x 8 reps | | | |
| Lat Pull Down | 3 x 8 reps | | | |
| Heel Raise | 3 x 8 reps | | | |
| Crunch | 3 x 25 reps | | | |
| X Cardiovascular | 25 min | | | |

**DAY 3**

| Rest between Sets | | Date | Date | Date |
|---|---|---|---|---|
| High Pull | 3 x 8 reps | | | |
| Weighted Sit-up | 3 x 8 reps | | | |
| Squat | 3 x 8 reps | | | |
| Heel Raise | 3 x 8 reps | | | |
| Nar. Bench Press | 3 x 8 reps | | | |
| DB Row | 3 x 8 reps | | | |
| Leg Extension | 3 x 8 reps | | | |
| Leg Curl | 3 x 8 reps | | | |
| X Cardiovascular | 25 min | | | |

NAME: _____

GROUP: Total S/P 45
TRAINER: _____

## DAY 1

| | | Rest between Sets | Date | Date | Date |
|---|---|---|---|---|---|
| | DB Clean & Press | 3 x 5 reps | | | |
| | Leg Curl | 3 x 8 reps | | | |
| | DB Incline Press | 3 x 5 reps | | | |
| | Front Pull Down | 3 x 8 reps | | | |
| | Squat | 3 x 5 reps | | | |
| | Incline Sit-up | 3 x 15 reps | | | |
| | Upright Row | 3 x 8 reps | | | |
| | DB Row | 3 x 8 reps | | | |
| X | Cardiovascular | 25 min | | | |

## DAY 2

| | | Rest between Sets | Date | Date | Date |
|---|---|---|---|---|---|
| | High Pull | 3 x 5 reps | | | |
| | Leg Curl | 3 x 8 reps | | | |
| | Bench Press | 3 x 5 reps | | | |
| | Seated Row | 3 x 5 reps | | | |
| | DB Press | 3 x 5 reps | | | |
| | Lat Pull Down | 3 x 8 reps | | | |
| | Heel Raise | 3 x 8 reps | | | |
| | Crunch | 3 x 25 reps | | | |
| X | Cardiovascular | 25 min | | | |

## DAY 3

| | | Rest between Sets | Date | Date | Date |
|---|---|---|---|---|---|
| | High Pull | 3 x 5 reps | | | |
| | Weighted Sit-up | 3 x 10 reps | | | |
| | Squat | 3 x 5 reps | | | |
| | Heel Raise | 3 x 8 reps | | | |
| | Nar. Bench Press | 3 x 5 reps | | | |
| | DB Row | 3 x 5 reps | | | |
| | Leg Extension | 3 x 8 reps | | | |
| | Leg Curl | 3 x 8 reps | | | |
| X | Cardiovascular | 25 min | | | |

NAME: _____ GROUP: Total S/P 46
TRAINER: _____

## DAY 1

| Rest between Sets | | Date Time In: Out: | Date Time In: Out: | Date Time In: Out: |
|---|---|---|---|---|
| DB Clean & Press | 3 x 3 reps | | | |
| Leg Curl | 3 x 6 reps | | | |
| DB Incline Press | 3 x 3 reps | | | |
| Front Pull Down | 3 x 6 reps | | | |
| Squat | 3 x 3 reps | | | |
| Incline Sit-up | 3 x 15 reps | | | |
| Upright Row | 3 x 5 reps | | | |
| DB Row | 3 x 5 reps | | | |
| X Cardiovascular | 25 min | | | |

## DAY 2

| Rest between Sets | | Date Time In: Out: | Date Time In: Out: | Date Time In: Out: |
|---|---|---|---|---|
| High Pull | 3 x 3 reps | | | |
| Leg Curl | 3 x 6 reps | | | |
| Bench Press | 3 x 3 reps | | | |
| Seated Row | 3 x 5 reps | | | |
| DB Press | 3 x 3 reps | | | |
| Lat Pull Down | 3 x 6 reps | | | |
| Heel Raise | 3 x 8 reps | | | |
| Crunch | 3 x 25 reps | | | |
| X Cardiovascular | 25 min | | | |

## DAY 3

| Rest between Sets | | Date Time In: Out: | Date Time In: Out: | Date Time In: Out: |
|---|---|---|---|---|
| High Pull | 3 x 3 reps | | | |
| Weighted Sit-up | 3 x 10 reps | | | |
| Squat | 3 x 3 reps | | | |
| Heel Raise | 3 x 8 reps | | | |
| Nar. Bench Press | 3 x 3 reps | | | |
| DB Row | 3 x 5 reps | | | |
| Leg Extension | 3 x 6 reps | | | |
| Leg Curl | 3 x 6 reps | | | |
| X Cardiovascular | 25 min | | | |

NAME: _____ GROUP: Upper Hyper
TRAINER: _____

## DAY 1

| Rest between Sets | | Date | Date | Date |
|---|---|---|---|---|
| 90 sec | Bench Press | 4 x 12 reps | | | |
| 90 sec | Seated Row | 4 x 12 reps | | | |
| 60 sec | DB Press | 3 x 12 reps | | | |
| 60 sec | Lat Pull Down | 3 x 12 reps | | | |
| 30 sec | EZ Curl | 3 x 12 reps | | | |
| 30 sec | Tricep Pushdown | 3 x 12 reps | | | |
| 60 sec | Rotational Crunch | 3 x 25 reps | | | |
| 60 sec | Back Extension | 3 x 12 reps | | | |
| X | Cardiovascular | 25 min | | | |

## DAY 2

| Rest between Sets | | Date | Date | Date |
|---|---|---|---|---|
| 90 sec | DB Incline Press | 3 x 12 reps | | | |
| 90 sec | Front Pull Down | 3 x 12 reps | | | |
| 60 sec | Upright Row | 3 x 12 reps | | | |
| 60 sec | DB Row | 3 x 12 reps | | | |
| 30 sec | DB Curl | 3 x 12 reps | | | |
| 30 sec | DB Tricep | 3 x 12 reps | | | |
| 60 sec | Sit-up | 3 x 25 reps | | | |
| X | Cardiovascular | 25 min | | | |

## DAY 3

| Rest between Sets | | Date | Date | Date |
|---|---|---|---|---|
| 90 sec | Bench Press | 4 x 12 reps | | | |
| 90 sec | Seated Row | 4 x 12 reps | | | |
| 60 sec | DB Press | 3 x 12 reps | | | |
| 60 sec | Lat Pull Down | 3 x 12 reps | | | |
| 30 sec | EZ Curl | 3 x 12 reps | | | |
| 30 sec | Tricep Pushdown | 3 x 12 reps | | | |
| 60 sec | Rotational Crunch | 3 x 25 reps | | | |
| 60 sec | Back Extension | 3 x 12 reps | | | |
| X | Cardiovascular | 25 min | | | |

NAME: _____

GROUP: Upper Hyper 48
TRAINER: _____

## DAY 1

| Rest between Sets | | | Date | Date | Date |
|---|---|---|---|---|---|
| 90 sec | Bench Press | 4 x 10 reps | | | |
| 90 sec | Seated Row | 4 x 10 reps | | | |
| 60 sec | DB Press | 3 x 10 reps | | | |
| 60 sec | Lat Pull Down | 3 x 10 reps | | | |
| 30 sec | EZ Curl | 3 x 10 reps | | | |
| 30 sec | Tricep Pushdown | 3 x 10 reps | | | |
| 60 sec | Rotational Crunch | 3 x 25 reps | | | |
| 60 sec | Back Extension | 3 x 10 reps | | | |
| X | Cardiovascular | 25 min | | | |

## DAY 2

| Rest between Sets | | | Date | Date | Date |
|---|---|---|---|---|---|
| 90 sec | DB Incline Press | 3 x 10 reps | | | |
| 90 sec | Front Pull Down | 3 x 10 reps | | | |
| 60 sec | Upright Row | 3 x 10 reps | | | |
| 60 sec | DB Row | 3 x 10 reps | | | |
| 30 sec | DB Curl | 3 x 10 reps | | | |
| 30 sec | DB Tricep | 3 x 10 reps | | | |
| 60 sec | Sit-up | 3 x 25 reps | | | |
| X | Cardiovascular | 25 min | | | |

## DAY 3

| Rest between Sets | | | Date | Date | Date |
|---|---|---|---|---|---|
| 90 sec | Bench Press | 4 x 10 reps | | | |
| 90 sec | Seated Row | 4 x 10 reps | | | |
| 60 sec | DB Press | 3 x 10 reps | | | |
| 60 sec | Lat Pull Down | 3 x 10 reps | | | |
| 30 sec | EZ Curl | 3 x 10 reps | | | |
| 30 sec | Tricep Pushdown | 3 x 10 reps | | | |
| 60 sec | Rotational Crunch | 3 x 25 reps | | | |
| 60 sec | Back Extension | 3 x 10 reps | | | |
| X | Cardiovascular | 25 min | | | |

NAME: _____

GROUP: Upper Hyper 49
TRAINER: _____

## DAY 1

| Rest between Sets | | Date Time In: Out: | Date Time In: Out: | Date Time In: Out: |
|---|---|---|---|---|
| 60 sec | Bench Press | 4 x 8 reps | | | |
| 60 sec | Seated Row | 4 x 8 reps | | | |
| 60 sec | DB Press | 3 x 8 reps | | | |
| 60 sec | Lat Pull Down | 3 x 8 reps | | | |
| 30 sec | EZ Curl | 3 x 8 reps | | | |
| 30 sec | Tricep Pushdown | 3 x 8 reps | | | |
| 30 sec | Rotational Crunch | 3 x 30 reps | | | |
| 30 sec | Back Extension | 3 x 8 reps | | | |
| X | Cardiovascular | 25 min | | | |

## DAY 2

| Rest between Sets | | Date Time In: Out: | Date Time In: Out: | Date Time In: Out: |
|---|---|---|---|---|
| 60 sec | DB Incline Press | 3 x 8 reps | | | |
| 60 sec | Front Pull Down | 3 x 8 reps | | | |
| 60 sec | Upright Row | 3 x 8 reps | | | |
| 60 sec | DB Row | 3 x 8 reps | | | |
| 30 sec | DB Curl | 3 x 8 reps | | | |
| 30 sec | DB Tricep | 3 x 8 reps | | | |
| 60 sec | Sit-up | 3 x 30 reps | | | |
| X | Cardiovascular | 25 min | | | |

## DAY 3

| Rest between Sets | | Date Time In: Out: | Date Time In: Out: | Date Time In: Out: |
|---|---|---|---|---|
| 60 sec | Bench Press | 4 x 8 reps | | | |
| 60 sec | Seated Row | 4 x 8 reps | | | |
| 60 sec | DB Press | 3 x 8 reps | | | |
| 60 sec | Lat Pull Down | 3 x 8 reps | | | |
| 30 sec | EZ Curl | 3 x 8 reps | | | |
| 30 sec | Tricep Pushdown | 3 x 8 reps | | | |
| 30 sec | Rotational Crunch | 3 x 30 reps | | | |
| 30 sec | Back Extension | 3 x 8 reps | | | |
| X | Cardiovascular | 25 min | | | |

NAME: _____ GROUP: Upper S/P 50
TRAINER: _____

**DAY 1**

| | Rest between Sets | | Date | | | Date | | | Date | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Bench Press | 3 x 8 reps | | | | | | | | | |
| | Seated Row | 3 x 8 reps | | | | | | | | | |
| | DB Press | 3 x 8 reps | | | | | | | | | |
| | Lat Pull Down | 3 x 8 reps | | | | | | | | | |
| | EZ Curl | 3 x 8 reps | | | | | | | | | |
| | Tri. Push Down | 3 x 8 reps | | | | | | | | | |
| | Incline Sit-up | 3 x 20 reps | | | | | | | | | |
| | Back Extension | 3 x 8 reps | | | | | | | | | |
| X | Cardiovascular | 25 min | | | | | | | | | |

**DAY 2**

| | Rest between Sets | | Date | | | Date | | | Date | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | DB Incline Press | 3 x 8 reps | | | | | | | | | |
| | Front Pull Down | 3 x 8 reps | | | | | | | | | |
| | Upright Row | 3 x 8 reps | | | | | | | | | |
| | DB Row | 3 x 8 reps | | | | | | | | | |
| | DB Curl | 3 x 8 reps | | | | | | | | | |
| | DB Tricep | 3 x 8 reps | | | | | | | | | |
| | Crunch | 3 x 25 reps | | | | | | | | | |
| X | Cardiovascular | 25 min | | | | | | | | | |

**DAY 3**

| | Rest between Sets | | Date | | | Date | | | Date | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Bench Press | 3 x 8 reps | | | | | | | | | |
| | Seated Row | 3 x 8 reps | | | | | | | | | |
| | DB Press | 3 x 8 reps | | | | | | | | | |
| | Lat Pull Down | 3 x 8 reps | | | | | | | | | |
| | EZ Curl | 3 x 8 reps | | | | | | | | | |
| | Tri. Push Down | 3 x 8 reps | | | | | | | | | |
| | Weighted Sit-up | 3 x 8 reps | | | | | | | | | |
| | Back Extension | 3 x 8 reps | | | | | | | | | |
| X | Cardiovascular | 25 min | | | | | | | | | |

NAME: _____ GROUP: Upper S/P 
TRAINER: _____

## DAY 1

| Rest between Sets | | | Date | | | Date | | | Date | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Bench Press | 3 x 5 reps | | | | | | | | | |
| | Seated Row | 3 x 5 reps | | | | | | | | | |
| | DB Press | 3 x 5 reps | | | | | | | | | |
| | Lat Pull Down | 3 x 8 reps | | | | | | | | | |
| | EZ Curl | 3 x 8 reps | | | | | | | | | |
| | Tri. Push Down | 3 x 8 reps | | | | | | | | | |
| | Incline Sit-up | 3 x 20 reps | | | | | | | | | |
| | Back Extension | 3 x 10 reps | | | | | | | | | |
| X | Cardiovascular | 25 min | | | | | | | | | |

## DAY 2

| Rest between Sets | | | Date | | | Date | | | Date | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | DB Incline Press | 3 x 5 reps | | | | | | | | | |
| | Front Pull Down | 3 x 8 reps | | | | | | | | | |
| | Upright Row | 3 x 5 reps | | | | | | | | | |
| | DB Row | 3 x 5 reps | | | | | | | | | |
| | DB Curl | 3 x 8 reps | | | | | | | | | |
| | DB Tricep | 3 x 8 reps | | | | | | | | | |
| | Crunch | 3 x 25 reps | | | | | | | | | |
| X | Cardiovascular | 25 min | | | | | | | | | |

## DAY 3

| Rest between Sets | | | Date | | | Date | | | Date | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Bench Press | 3 x 5 reps | | | | | | | | | |
| | Seated Row | 3 x 5 reps | | | | | | | | | |
| | DB Press | 3 x 5 reps | | | | | | | | | |
| | Lat Pull Down | 3 x 8 reps | | | | | | | | | |
| | EZ Curl | 3 x 8 reps | | | | | | | | | |
| | Tri. Push Down | 3 x 8 reps | | | | | | | | | |
| | Weighted Sit-up | 3 x 10 reps | | | | | | | | | |
| | Back Extension | 3 x 10 reps | | | | | | | | | |
| X | Cardiovascular | 25 min | | | | | | | | | |

NAME: _____ GROUP: Upper S/P 52
TRAINER: _____

**DAY 1**

| Rest between Sets | | | Date Time In: | Out: | Date Time In: | Out: | Date Time In: | Out: |
|---|---|---|---|---|---|---|---|---|
| | Bench Press | 3 x 3 reps | | | | | | |
| | Seated Row | 3 x 5 reps | | | | | | |
| | DB Press | 3 x 3 reps | | | | | | |
| | Lat Pull Down | 3 x 6 reps | | | | | | |
| | EZ Curl | 3 x 6 reps | | | | | | |
| | Tri. Push Down | 3 x 6 reps | | | | | | |
| | Incline Sit-up | 3 x 20 reps | | | | | | |
| | Back Extension | 3 x 8 reps | | | | | | |
| X | Cardiovascular | 25 min | | | | | | |

**DAY 2**

| Rest between Sets | | | Date Time In: | Out: | Date Time In: | Out: | Date Time In: | Out: |
|---|---|---|---|---|---|---|---|---|
| | DB Incline Press | 3 x 3 reps | | | | | | |
| | Front Pull Down | 3 x 6 reps | | | | | | |
| | Upright Row | 3 x 5 reps | | | | | | |
| | DB Row | 3 x 5 reps | | | | | | |
| | DB Curl | 3 x 6 reps | | | | | | |
| | DB Tricep | 3 x 6 reps | | | | | | |
| | Crunch | 3 x 25 reps | | | | | | |
| X | Cardiovascular | 25 min | | | | | | |

**DAY 3**

| Rest between Sets | | | Date Time In: | Out: | Date Time In: | Out: | Date Time In: | Out: |
|---|---|---|---|---|---|---|---|---|
| | Bench Press | 3 x 3 reps | | | | | | |
| | Seated Row | 3 x 5 reps | | | | | | |
| | DB Press | 3 x 3 reps | | | | | | |
| | Lat Pull Down | 3 x 6 reps | | | | | | |
| | EZ Curl | 3 x 6 reps | | | | | | |
| | Tri. Push Down | 3 x 6 reps | | | | | | |
| | Weighted Sit-up | 3 x 8 reps | | | | | | |
| | Back Extension | 3 x 10 reps | | | | | | |
| X | Cardiovascular | 25 min | | | | | | |

# APPENDIX 2

## Abstract Presented at the National Strength and Conditioning Association Meeting Atlanta, GA June 1996

# ACUTE RESISTANCE EXERCISE IN WOMEN REDUCES LYMPHOCYTE PROLIFERATION RESPONSE TO MITOGENS

K. Dohi., W. J. Kraemer., A. M. Mastro., M. P. Miles., D. Grove., S. Leach., B. Nindl., and J. A. Bush. Center for Sports Medicine and Center for Cell Research, The Pennsylvania State University, University Park, PA 16802

To determine the influence of muscular strength on lymphocyte proliferation after acute heavy resistance exercise as a measure of immunologic function in active, healthy but non-strength trained women were recruited for the study. The top and bottom eight women (X±SD; 22.5 ± 3.1 yrs) were obtained from a total strength testing distribution of 50. The two groups were based on a significant ($p \leq 0.05$) difference in 1 RM squat strength (low 39.9 ± 4.6 kg, 0.65 ± 0.08 $kg \cdot kg^{-1} \cdot BM^{-1}$ and high 72.2 ± 10.7 kg, 1.1 ± 0.12 $kg \cdot kg^{-1} \cdot BM^{-1}$) and no significant difference in body mass. Each participated in an exercise testing session consisting of six sets of 10 RM squat with two minutes rest between the sets. Blood samples were obtained pre-exercise and five minutes post exercise. Lymphocyte responses to pokeweed mitogen (PWM) were determined through the incorporation of triated thymidine. The squat exercise significantly decreased lymphocyte responses to PWM in high strength (but not in low strength) group for both total proliferation and proliferation adjusted on a per B and T cell basis. These data indicate that the squat exercise transiently reduced lymphocytes' proliferative responses to PWM in stronger individuals. This effect may be due to the high absolute total work and the greater exercise stress from the resistance exercise protocol in the high strength group. Intense exercise workouts may cause a transient depression in immune function, especially in women who have a greater functional capacity (i.e., higher 1RM), thereby making them potentially more susceptible to pathogens immediately after a workout.

*Supported by Dept. of the Army #DAMD 17-95-C-5069*

# APPENDIX 3

## Preliminary Assay Work Ups on Growth Hormone

# Initial verification stages of primary methodologies (3 months)

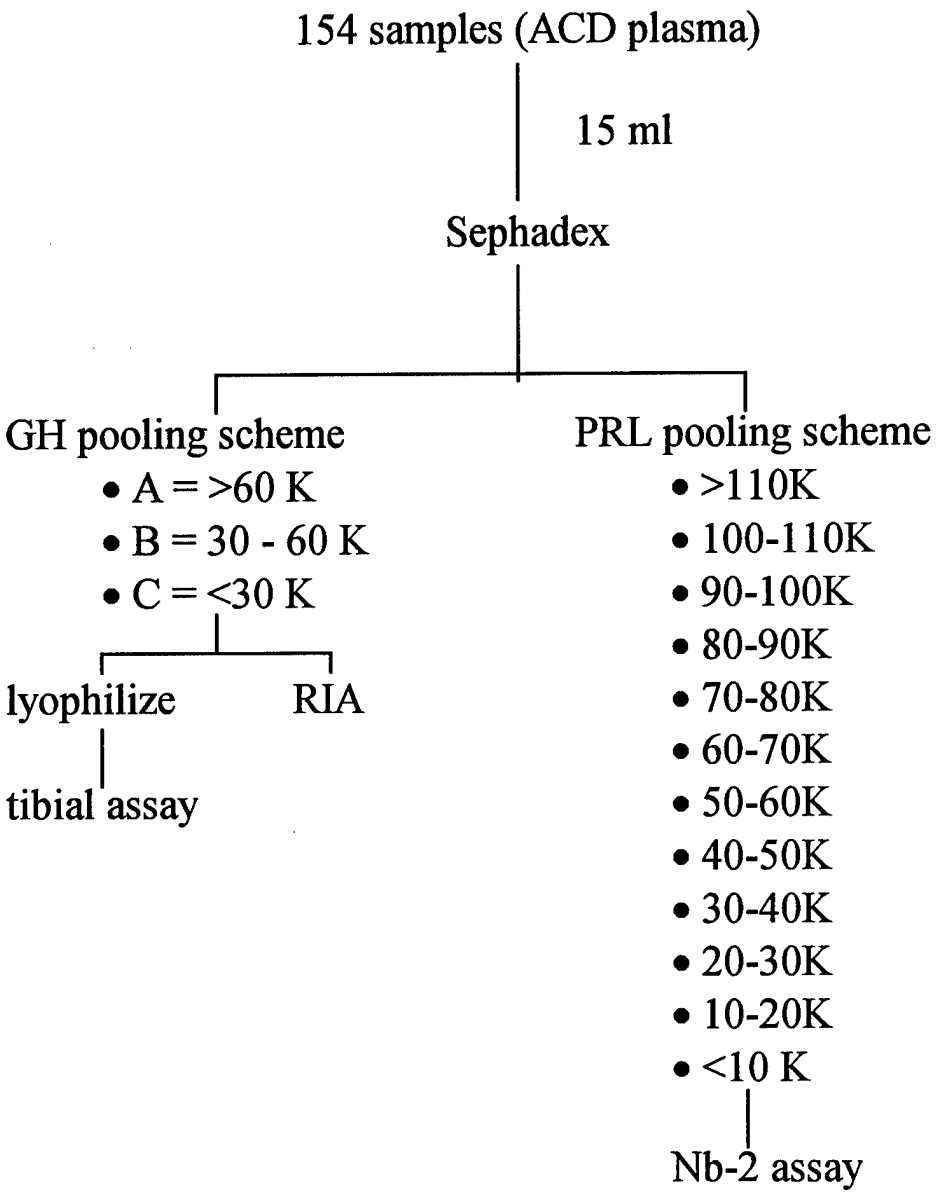
## Objectives:

1) Establish procedures for processing multiple samples on Sephadex (Sephacryl) G-100 columns.

2) Verify operations using molecular weight standards.

3) Protein (OD 280), GH (RIA), and PRL (Nb-2) contents of each fraction eluting from the Sephadex column (#=150) using a single plasma sample before exercise and after exercise.

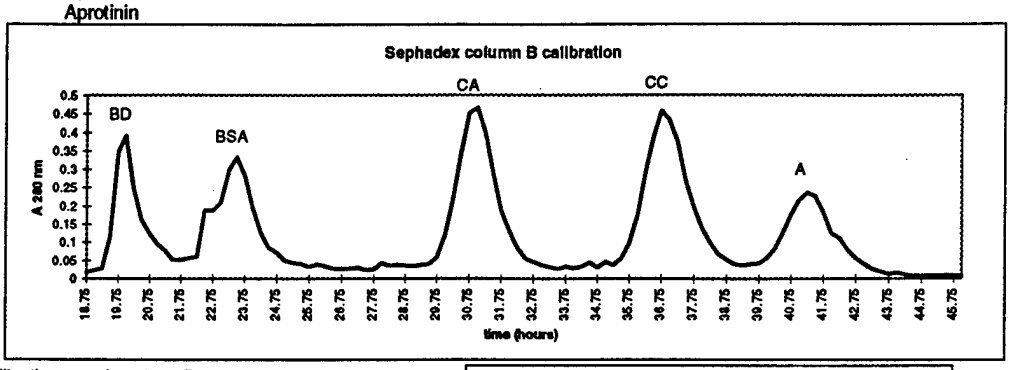
# Standard processing operations for $T_1$ and $T_3$ (total = 154)



## Results document reproducibility of column operations

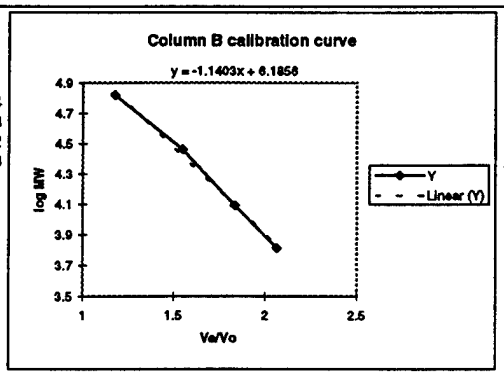
Molecular weight standards used:

Blue Dextran
BSA
Carbonic anhydrase
Cytochrome C
Aprotinin




Calibration curve for column B

| | Ve | Ve/Vo | MW | log MW |
|---|---|---|---|---|
| Blue Dextran ( | 20 | 1 | 2000000 | 6.30103 |
| BSA | 23.5 | 1.175 | 66000 | 4.819544 |
| Carbonic Anhyd | 31 | 1.55 | 29000 | 4.462398 |
| Cytochrome | 36.75 | 1.8375 | 12400 | 4.093422 |
| Aprotinin | 41.25 | 2.0625 | 6500 | 3.812913 |




SUMMARY OUTPUT

*Regression Statistics*

| | |
|---|---|
| Multiple R | 0.997316 |
| R Square | 0.994639 |
| Adjusted R | 0.991959 |
| Standard E | 0.0393 |
| Observatio | 4 |

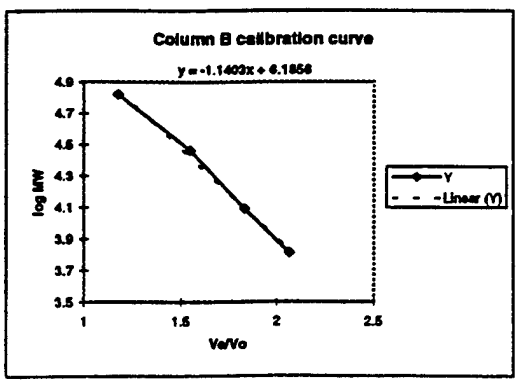
ANOVA

| | *df* | *SS* | *MS* | *F* | *ignificance F* |
|---|---|---|---|---|---|
| Regressior | 1 | 0.573104 | 0.573104 | 371.0678 | 0.002684 |
| Residual | 2 | 0.003089 | 0.001544 | | |
| Total | 3 | 0.576193 | | | |

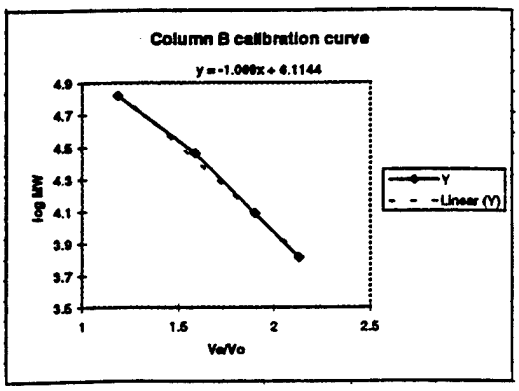
| | *Coefficients* | *tandard Err* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *ower 95.0%* | *pper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 6.18563 | 0.09999 | 61.86247 | 0.000261 | 5.755407 | 6.615853 | 5.755407 | 6.615853 |
| X Variable | -1.14026 | 0.059194 | -19.2631 | 0.002684 | -1.39495 | -0.88557 | -1.39495 | -0.88557 |

| *Observatior* | *Predicted Y* | *Residuals* |
|---|---|---|
| 1 | 4.863281 | -0.04374 |
| 2 | 4.387663 | 0.074735 |
| 3 | 4.070584 | 0.022837 |
| 4 | 3.866748 | -0.05383 |

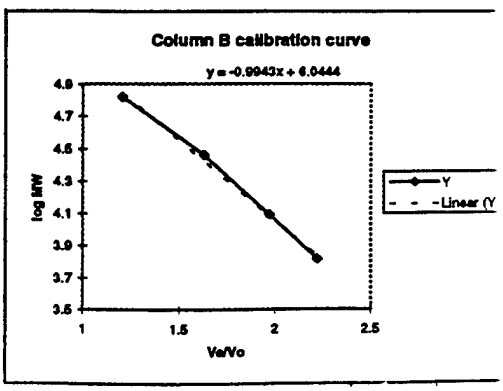
**Run #1**




**Run #2**




**Run #3**



**Preliminary results of standard processing operations show that:**

1) pooling scheme will satisfactorily differentiate iGH forms (panel A)

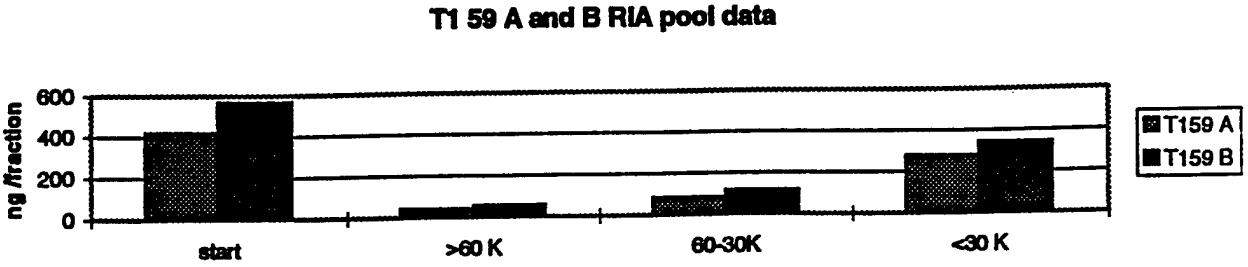
2) pretreatment of pools with reducing agent (GSH) had little effect on distribution profiles of iGH (panel B)

3)the plasma sample after exercise contains more iGH (panel A). About 60 % of the total recovered GH is in the <30K fraction. Recoveries of iGH after Sephadex average 92%.

A and B pool RIA data without GSH

| | A(ng/ml) | volume (ml) | total on column | % of total | B(ng/ml) | volume (ml) | total on column | % of tot |
|---|---|---|---|---|---|---|---|---|
| start | 20.871 | 20 | 417.42 | | 28.328 | 20 | 566.52 | |
| >60 K | 0.835 | 45 | 37.575 | 9.001725 | 0.885 | 63 | 55.755 | 9.84166 |
| 60-30K | 1.333 | 60 | 79.98 | 19.16056 | 1.863 | 60 | 111.78 | 19.7305 |
| <30 K | 1.531 | 180 | 275.58 | 66.01984 | 2.907 | 117 | 340.119 | 60.0365 |
| | | total pools | 393.135 | | | total pools | 507.654 | |
| | | % recovery | 94.18211873 | | | % recovery | 89.60919297 | |

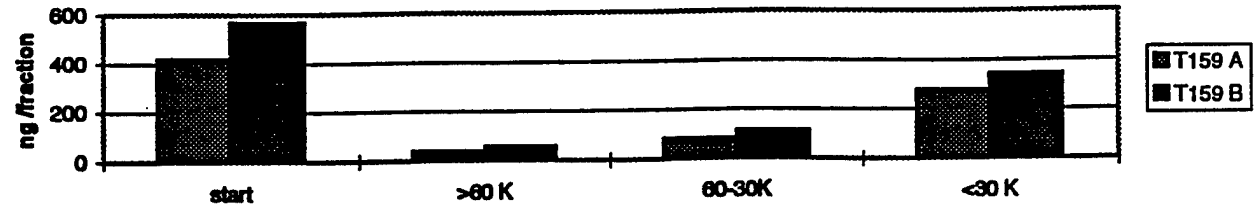
**A**




A and B pool RIA data with GSH

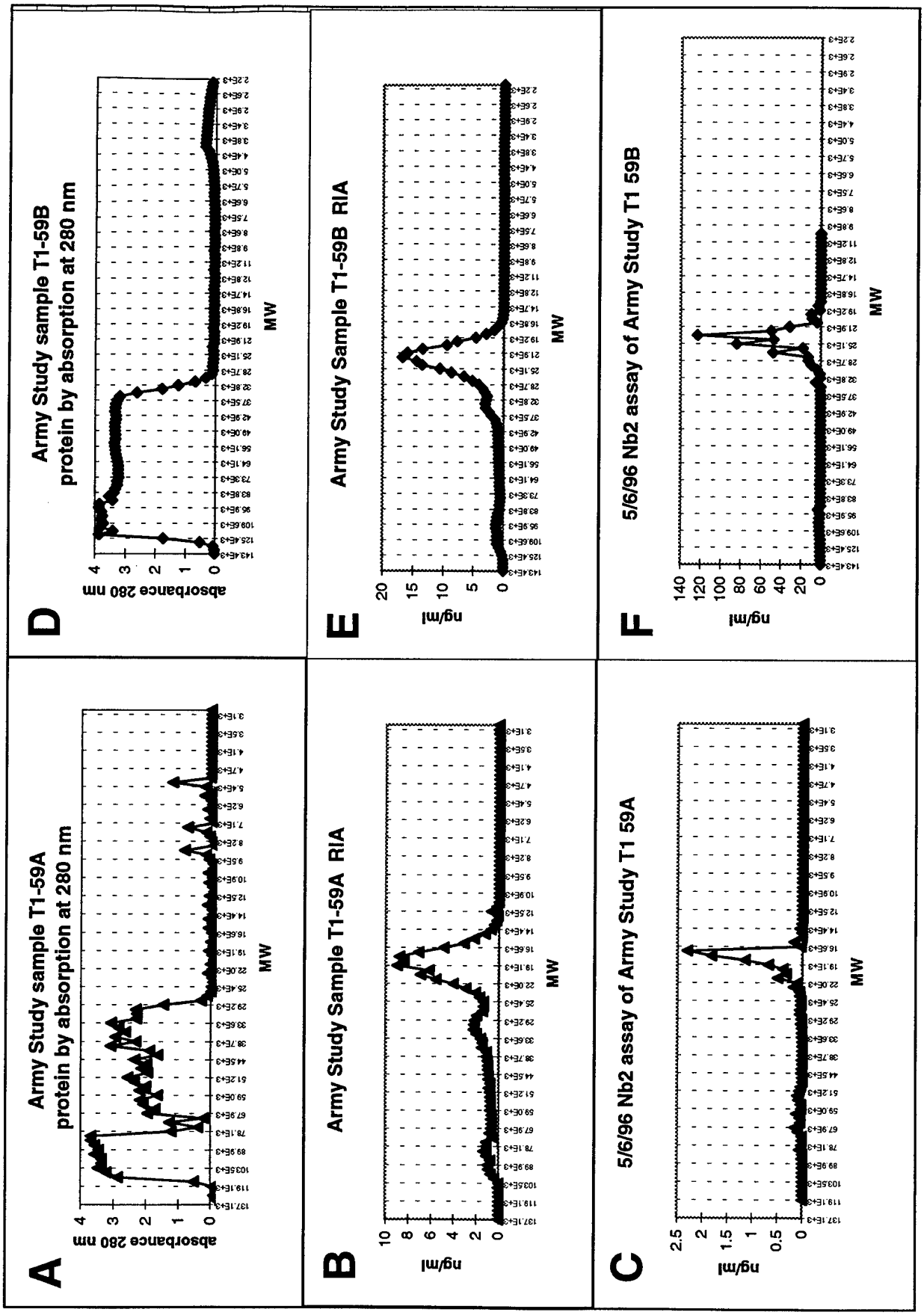
| | A(ng/ml) | volume (ml) | total on column | % of total | B(ng/ml) | volume (ml) | total on column | % of to |
|---|---|---|---|---|---|---|---|---|
| start | 21.932 | 20 | 438.64 | | 27.425 | 20 | 548.5 | |
| >60 K | 0.895 | 45 | 40.275 | 9.648555 | 1.027 | 63 | 64.701 | 11.420 |
| 60-30K | 1.554 | 60 | 93.24 | 22.33721 | 1.863 | 60 | 111.78 | 19.730 |
| <30 K | 1.492 | 180 | 268.56 | 64.33808 | 2.496 | 117 | 292.032 | 51.54 |
| | | total pools | 402.075 | | | total pools | 468.513 | |
| | | % recovery | 91.66400693 | | | % recovery | 85.41713765 | |

**B**




4) 231 samples from the $T_1/T_3$ study done to date are currently in assay for iGH

5) 20 samples have been assayed for their lactogenic activity using the Nb-2. Preliminary results suggest that exercise specifically increases a high molecular weight form of a GH/PRL species.


A
Army Study sample T1-59A
protein by absorption at 280 nm
absorbance 280 nm
MW
B
Army Study Sample T1-59A RIA
ng/ml
MW
C
5/6/96 Nb2 assay of Army Study T1 59A
ng/ml
MW
D
Army Study sample T1-59B
protein by absorption at 280 nm
absorbance 280 nm
MW
E
Army Study Sample T1-59B RIA
ng/ml
MW
F
5/6/96 Nb2 assay of Army Study T1 59B
ng/ml
MW

## Results from analysis of 150 individual fractions from a single plasma sample pre- and post- exercise show that:

- GH and PRL have slightly different apparent molecular weights in the pre-exercise sample (compare panels B and C). The same is true after exercise (compare panels E and F).

- The molecular weight range of the majority of the immunoreactive GH (iGH) is 15-38 kD.

- There is a small amount (<7%) of iGH that has high apparent molecular weight (70-110 kD).

- Exercise has no effect on the apparent molecular weights of iGH; however, there was a greater concentration of iGH in the exercise sample.

- The concentration of lactogenic hormones (PRL+GH) in these same plasma samples was very different between the pre- and post- exercise (compare scales in panels C and F).

- Protein profiles indicate more material in plasma after exercise (compare panels A and D)